

# ENVIRONMENTAL monitor

SUMMER 2016

APPLICATION AND TECHNOLOGY NEWS FOR ENVIRONMENTAL PROFESSIONALS

## SIPPO LAKE SEDIMENT QUESTIONS



### Flint Water Crisis

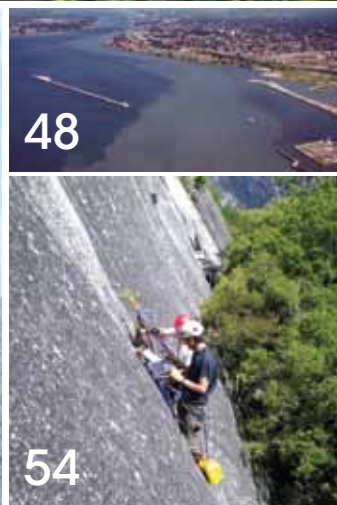
GIS Effort Maps City's Lead Pipes

### Ohio Stream Monitoring

A Visit To The National Center For Water Quality Research

### Tradeoffs To Green Infrastructure

Do Constructed Wetlands Do More Harm Than Good?



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The High Lakes Aquatic Alliance Foundation deploys a NexSens CB-450 buoy in Suttle Lake to gather water quality info ahead of a salmon restoration project.

Cover Photo: Daniel Kelly / Fondriest Environmental

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**WELCOME...**

Welcome to the Summer 2016 edition of the Environmental Monitor, a quarterly collection of the best of our online news publication. In this edition, we take you on location with researchers around the Great Lakes tackling important scientific questions.

This includes a visit to the National Center for Water Quality Research at Heidelberg University, where investigators oversee 18 monitoring stations gathering valuable stream quality data used in Lake Erie algae forecasting. From there, we hop over to Canton, Ohio, where Stark County park officials have installed sondes and data loggers to learn if efforts to reduce sediment loads are working. Then we meet with Northern Kentucky University scientists trying to dissect the tradeoffs of artificial wetlands – Sure, they improve water quality, but is that benefit offset by their greenhouse gas emissions?

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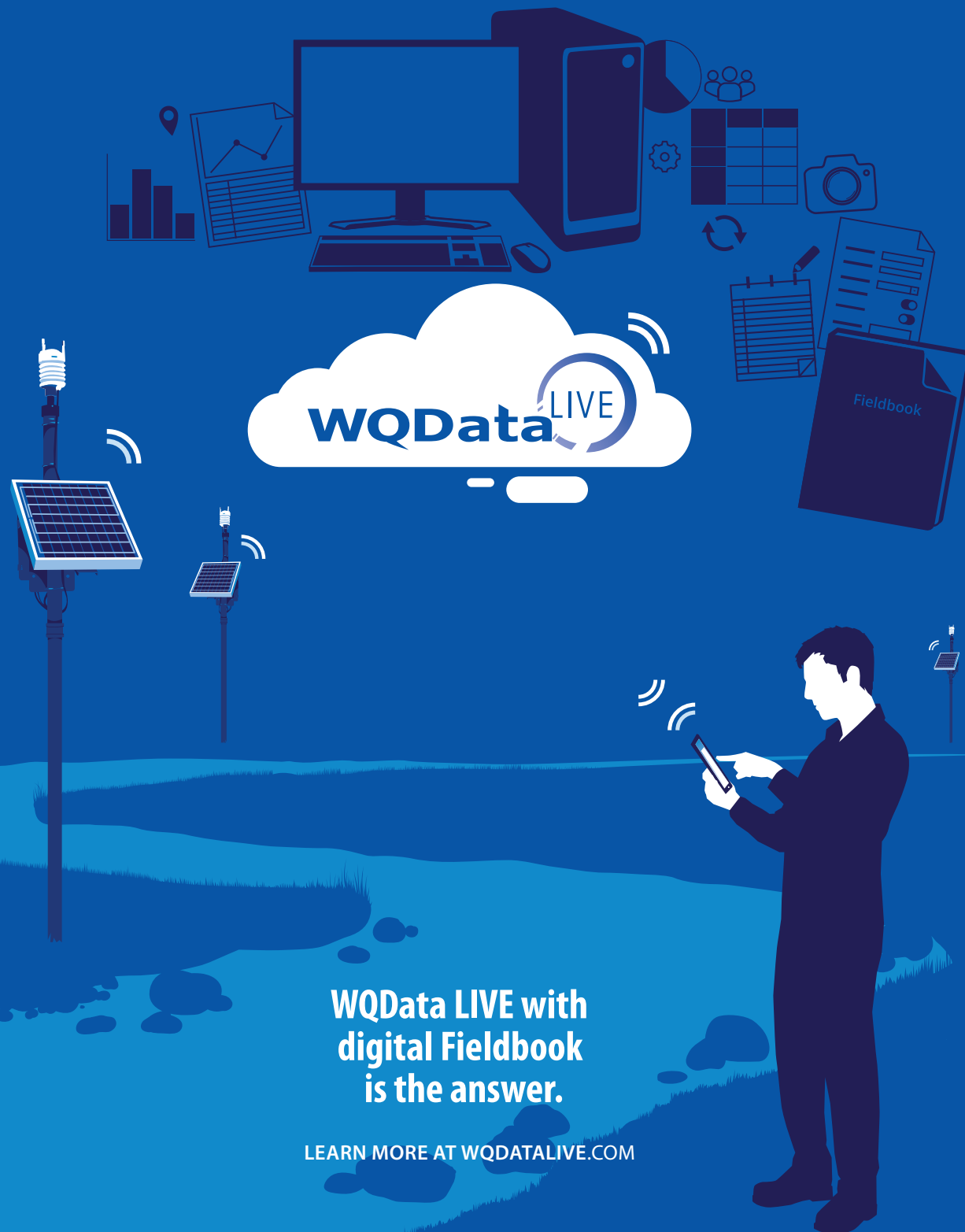
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## WEB EXCLUSIVES

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### Air Quality Near Fracking: Highest Emissions During Flowback

Colorado's Garfield County has some of the highest oil and gas activity in the state. Not surprisingly, there is a lot of concern locally about air quality near fracking operations there.

A recent investigation led by scientists at Colorado State University has documented the constituents that rise off the county's natural gas wells from the beginning of gas exploration, involving drilling, fracking and ultimately the collection of gas. The results of the work will be used in an upcoming statewide human health risk assessment planned by the Colorado Department of Public Health and Environment and also have implications for other parts of the nation.

The findings point to an interesting discovery: More volatile organic compound (VOC) emissions come during flowback operations, which is when water and fracking fluids flow up from the ground following hydraulic fracturing. Colorado State U. scientists say they weren't surprised at the find, noting that their original hypothesis was that the flowback period would convey the highest emissions.

### OpenCTD: Open-Source Sensor Ready For Seas

A few years back, the OpenCTD was just an idea. At that time, the device's developers were talking in terms of its first blueprints and were still trying to achieve a conductivity measurement using a custom-built sensor made with two flat washers relying on Ohm's law.

But it's been three years since that conceptual phase. Where is the OpenCTD now? Is it ready for more widespread use by oceanographers and others interested in gathering marine data?

We can gladly report that its design is complete and thoroughly improved over what it used to be. And anyone who would like to build their own can easily do so by downloading instructions and a bill of materials from Oceanography for Everyone's GitHub.

The OpenCTD has progressed by bounds since its inception. One of its developers, Andrew Thaler, a visiting scientist at the Virginia Institute of Marine Science, tells us that the device has made it through its first phase. He developed the OpenCTD with Kersey Sturdivant, McCurdy Visiting Scholar at Duke University's Nicholas School of the Environment.



### Studying Chesapeake Bay Shallows to Preserve Key Habitats

Chesapeake Bay is the largest estuary in the United States and one of the most productive bodies of water in the world. This is especially true for its shallow waters, where underwater grass beds serve as habitats and nursery grounds for juvenile fish and other aquatic life.

Because of the roles that these areas play in supporting the bay's health, managers with the Maryland Department of Natural Resources are understandably interested in keeping tabs on how their conditions change over time.

"...Maintaining good water quality in these habitats is crucial to sustaining viable populations of Maryland's living resources," said Brian Smith, program manager of monitoring integration with the DNR.

To do this, Smith and other scientists at the DNR have set up multiple monitoring stations around the bay. Seven of these are NexSens 3100-MAST systems that collect readings from YSI water quality sondes and then transmit them back to researchers via cellular telemetry.

Photo: (top) Colorado State University; (center) Andrew Thaler / Oceanography for Everyone; (bottom) Maryland Department of Natural Resources

# IN THE NEWS



## Hudson River Wetlands May Increase With Rising Seas

Cornell University scientists have predicted the fate of Hudson River wetlands in the future, according to a release. And in spite of predicted climate change and rising seas, researchers say that wetlands along the river are likely to increase in area.

Using a Sea Level Affecting Marshes Model (SLAMM), investigators simulated wetland conversions and shoreline changes that could affect tidal habitats. The model was originally developed for brackish wetlands but was adapted for studying the Hudson River, a freshwater estuary.

Researchers used 20-year intervals in their simulations to predict estuary changes that could take place with rising waters from the Atlantic Ocean at the river's mouth. They saw that there will likely be great shifts in the composition of the river's wetlands, with wide conversions of dry, or high, marsh habitat to wetter low marsh as well as some permanent flooding.



## Cameras Capture Sediment Shifts After Millie Turner Dam Removal

Researchers at Keene State College are investigating the effects of dam removal on downstream sediment deposition, according to a release. Their work is taking place on the Nissitissit River in Massachusetts where the Millie Turner Dam was recently removed.

Scientists at the university, including student researchers, documented sediments in the river upstream and downstream of the dam before its removal. Not surprisingly, areas downstream were starved of sediment before the dam came down. But the big question was really how quickly sediments would surge downstream after the Millie Turner Dam was removed. There was concern that too much too fast could harm aquatic life, including a rare mussel species living there.

To answer that question, investigators have used underwater cameras to document sediments in the river. With the dam removed in 2015, their work has shifted to focus on the impacts. The investigation is still ongoing, but has so far revealed that sediments aren't returning downstream as quickly as some had predicted.



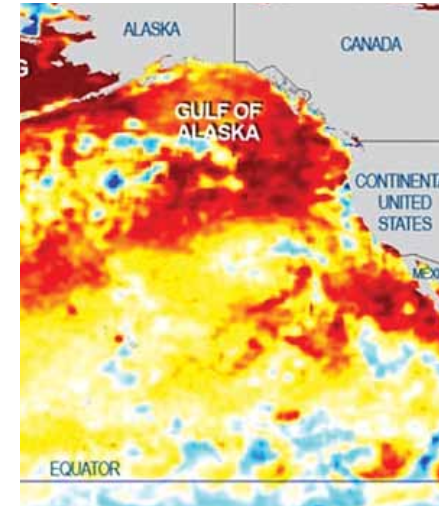
## GPS Trackers Find Frigate Birds Stay Aloft Up To Two Months

Scientists have long known that great frigate birds can fly for days at a time. But thanks to a recent investigation completed by researchers at the French National Center for Scientific Research, we now know that frigates can fly for much longer than that — up to two months continuously.

Investigators used low-weight GPS trackers mounted on the necks of four dozen frigates over the course of 2011 to 2015. These recorded the movements of the birds, while other sensors within monitored the birds' heart rates. Accelerometers and altimeters were also a part of the payload and tracked the birds' location in the sky and acceleration.

Through their efforts, scientists found that frigate birds could stay aloft for remarkably longer than once thought at amazing heights. Some birds reached altitudes as far up as 2.5 miles, where oxygen is thin and water freezes. Researchers likewise uncovered that the birds can glide for hundreds of miles while only flapping their wings every six minutes.

Photo: (left) Robert Rodriguez; (center) Keene State College; (right) Dick Daniels / CC-BY-SA 3.0



## 'The Blob' And El Niño Harmed Pacific Ocean Productivity

El Niño had huge impacts on conditions around the world through parts of 2015 and 2016, including beach erosion in California, drought in South America and record rainfall in the United States' Pacific Northwest. We have covered those and other impacts in this magazine as well as published an infographic detailing the phenomenon. But we haven't talked much about a patch of warm water in the Pacific Ocean known as "the Blob."

Scientists at the University of California, Santa Cruz, have recently led research into some of the impacts the Blob had over the last year. There was a lot of speculation concerning which weather phenomenon would be more dominant in the Pacific. To investigate, data for the effort were gathered by autonomous gliders as well as ocean models.

Together with El Niño, researchers found that the Blob helped to strongly depress productivity off the West Coast. The Blob, in fact, seemed to drive most of the impact because El Niño was weaker than expected.

Photo: (left) NOAA; (right) NASA and U.S. Geological Survey



## Utah Lake Algae Fed By Wastewater

A massive Utah Lake algae bloom covered more than 90 percent of the state's largest freshwater lake in July 2016, according to multiple reports. Officials there say the main culprit was human waste, and the phosphorus it carries, discharged from eight wastewater treatment plants nearby.

The result of all that discharge was a thick and gooey green slime coating Utah Lake and rendering its waters useless to boaters and fishermen. The lake was closed July 15, due to the health risks the bloom posed, by the Utah Department of Environmental Quality.

Since that time, water sampling continued around Utah Lake and the Jordan River, which carries water from the water body to Great Salt Lake downstream. Scientists were mostly concerned with levels of any toxins produced by the algae, including microcystins, that can be fatal to pets or livestock. In humans, these can cause rashes, dizziness or liver failure if ingested.



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## Alkaline Castor Lake

A common method used in studying lakes is sediment core analysis. But sometimes assessing cores isn't as straightforward as researchers would like, with inaccuracies coming into play when they begin to inspect geochemical changes evident in core records.

But as with a lot of studies into lakes and their pasts, scientists are always working to make their methods for studying these valuable bodies of water more reliable. In one example of this, researchers at the University of Minnesota's Large Lakes Observatory have instrumented a couple of lakes in Washington state with Solinst Levelogger Edge Water Level Loggers and other sensors that they hope can yield findings that will one day illuminate their understanding of the changes lakes undergo over time.

The two lakes of interest are Castor Lake and Scanlon Lake, both alkaline water bodies sitting above the Lime Belt in Okanogan County. This area is in north-central Washington.

"We are studying modern lake-catchment hydrologic and isotopic responses to seasonal changes in precipitation and evaporation. This information will help us to better interpret lake sediment records of past hydroclimate change," said Byron Steinman, assistant professor in the Department of Earth and Environmental Sciences. "Both Castor and Scanlon Lake sediments contain abundant authigenic calcium carbonate that we have analyzed to produce paleo records of oxygen isotope variability spanning the Holocene."

His hope for monitoring the lakes, which includes tracking surface water temperatures, lake levels and groundwater elevation changes with the help of some shallow wells surrounding them, is to make it easier for himself and other scientists to interpret the geochemical changes that are recorded in lake sediment records.

Steinman and his students have been venturing out at least once a year to download data gathered by the leveloggers and other instruments around the two lakes.

"We have a 10-year continuous dataset now that is pretty cool," said Steinman.

As for what the data show, a little analysis is underway to uncover findings for some of the more recent years. But there have been a few surprises over the course of the investigation.

"Lake level changes seasonally more than we originally anticipated and responds more strongly to cold season precipitation and snowpack than to summer temperatures," said Steinman.

In the future, Steinman plans on publishing those and other results in peer-reviewed journals like *Limnology and Oceanography*, *Geochimica*, *PNAS* and *Quaternary Science Reviews*.

"We anticipate developing a better, more quantitative understanding of how small, closed-basin lakes in the Pacific Northwest respond to seasonality and climate change," said Steinman.

*Photo: University of Pittsburgh*



## Tide Pools at Night | Carnegie Institution for Science

A lot of things that occur in nature can be considered scary. Forest fires, earthquakes and volcanic eruptions all seem to be good examples. But what about darkness? For some calcifying organisms living in coastal tide pools, darkness can be downright terrifying.

That's because of the impacts that nightfall has on the plants living around them, according to research led by scientists at the Carnegie Institution for Science. When night falls, these plants begin respiring, instead of relying on photosynthesis for energy, which can greatly impact the carbon dioxide levels in surrounding seawater.

In their investigation, Carnegie researchers joined with others at the University of California, Davis, to instrument four coastal tide pools at the Bodega Marine Reserve. Measurements of conductivity, temperature and depth were gathered using YSI 6600 water quality sondes, while pumps were used to collect discrete water samples for analysis back in the lab.

Scientists considered the depths, volumes and community structures of each pool they encountered. The dominant calcifying organisms in all of the pools were coralline algae and crustose coralline algae, but also found were bivalve mollusks and creatures that have shells, like snails.

The seawater chemistry and its changes were tracked during mostly the early summer months (April, May and June) of 2014 and 2015 on hourly timescales during five visits to the pools at low tide, when they are isolated from the open ocean. The sampling periods in 2014 took place during the daytime and those occurring in 2015 were carried out at night.

The data showed that conditions in the tide pools got better for calcifying organisms during the day. But through the night time, plant respiration influenced the seawater's pH enough to make the pools dangerously acidic for the creatures. The rates at which the organisms' shells dissolved were increased by the nighttime changes, researchers found.

"This work highlights that even in today's temperate coastal oceans, calcifying species, such as mussels and coralline algae, can dissolve during the night due to the more-acidic conditions caused by community respiration," said Lester Kwiatkowski, a research scientist at Carnegie and the study's lead author, in a statement.

While scientists didn't assess how photosynthesizing calcifiers, like calcifying algae, did on an individual basis, they think that their findings overall will help predictions in the future relating to daytime calcification on community scales.

Photo: Lester Kwiatkowski / Carnegie Institution for Science



## Coastal Aquifers | University of Delaware

We see a lot of things when we visit beaches — like seagulls, shells or sand castles. But it's what we don't see that may be most important for ensuring the quality of the vacation we have. That is, the exchange that occurs between the salty ocean water out in the open and the fresh groundwater held in coastal aquifers below.

Though it seems like water mixing with water might not be such a big deal, it actually matters more than you'd think. This is because the groundwater coming off land can contain high levels of nutrients, like nitrogen and phosphorus from agricultural activities, that simply aren't found in such high concentrations in ocean water. If there's too much nutrient-rich groundwater getting to those nearshore waters, they can spur algal blooms or lead to fish kills.

Researchers at University of Delaware have charted the fluctuations that go on between saltwater and groundwater in a coastal aquifer during different times of the year. The effort was carried out at Delaware's Cape Henlopen State Park, where scientists set up multiple groundwater sampling wells in a transect running from below the tide line up to the sand dunes on a beach.

There were 10 groundwater wells used in the effort, from which scientists gathered samples using pumps to pull water to the surface. This was pretty straightforward unless the tide was high.

Photo: University of Delaware

In that situation, researchers had to run tubing under the sand until it reached the target well and then pump water out vertically and then horizontally. After gathering the samples, each one was assessed for its conductivity, which is a marker of salinity.

This type of sampling continued over the course of a year, with consideration for the variability of tidal stages, tidal range and changes occurring due to the water table height on land. The study period fortunately overlapped with Hurricane Sandy, permitting researchers to assess the effects of a storm on coastal aquifer dynamics.

But the effects were short-lived and fairly minimal. There was a small spike in freshwater coming in and changes in salinity were not as large as expected. There weren't many changes in the salinity distribution over the tidal cycle, but the spring tide (occurs twice a month) had higher mixing activity than neap tide.

"The mixing is important because saltwater is different than freshwater, the mixing of groundwater. That is different chemically," said James Heiss, a doctoral candidate studying coastal hydrogeology in the university's Department of Geological Sciences and the study's lead author. "We're trying to understand how the physical system, the flow, the transport of salt, affects the biogeochemistry of the beach."

# FLINT'S LEAD PIPES

University of Michigan - Flint scientists use a GIS approach to map Flint water pipes and pinpoint the ones most likely containing lead.

BY DANIEL KELLY

The City of Flint, Michigan's drinking water woes have been national news for nearly a year. So have the difficulties that those working on the ground have dealt with.

One headache, which isn't altogether uncommon for any American city, is poor record-keeping. As folks working to respond to the high levels of lead in the city's water found, Flint's water utility didn't have data showing the precise locations of lead pipes in the city.

So when researchers at the University of Michigan - Flint set out to begin a GIS mapping effort to document where city pipes were located, even before the current state of emergency declared in January, they found that there was little to work with.

"We approached the city back in October (2015). It was after the state of emergency that a couple of other agencies started mapping," said Marty Kaufman, professor and chair of the Department of Earth and Resource Science at the university. He is leading an effort to map all the city's water pipes to pinpoint where the lead ones are. "The records were on some type of spreadsheet that looked like something out of the library I grew up using in middle school. That was in the 1960s when we didn't have automatic record-keeping."

It was surprising that the records were so lacking, Kaufman says, simply because the water utility is a fairly large one that oversees drinking water for more than 100,000 people. But to make up for the holes in the data, he and others had to find a workaround.

That process began with taking digital images that the city had showing the existence of water pipes, typically marked with letters indicating what metal they were made of. Copper pipes, for example, were marked with a "C," while lead ones were marked with an "L." From there, it was a matter of decrypting the letters, which were sometimes hard to make out, and then transferring them to parcel maps.

"We can georeference them with an existing database of parcels," said Kaufman. "By copying the code from plastic images into a real database, that allows us to look for clusters of pipes. That allows association to lead levels." There were some parcels that didn't have markings indicating what type of pipes were used, so physical inspections will need to be done on those, Kaufman says.

The effort has pretty much wrapped up, but is in a quality-control phase right now. Researchers are adding metadata to the maps that they've created to offer descriptions that will help those who use them have an easier experience. The metadata will also help Kaufman's crew as their work into the drinking water problems continues, such as helping construction workers looking for lead pipes or predicting where medical problems — like high levels of lead in blood — may be prevalent.

And there are some useful insights to report. Kaufman says that most of the lead pipes are ones that branch off of main channels and link directly to homes.

"That's where the lead is. There's a potential for lead in the mains in bell and spigot joints made before 1950, which may have lead as a joiner," said Kaufman. "It's unlikely, but it's possible. It's hard to know because the records in the city were very poor."

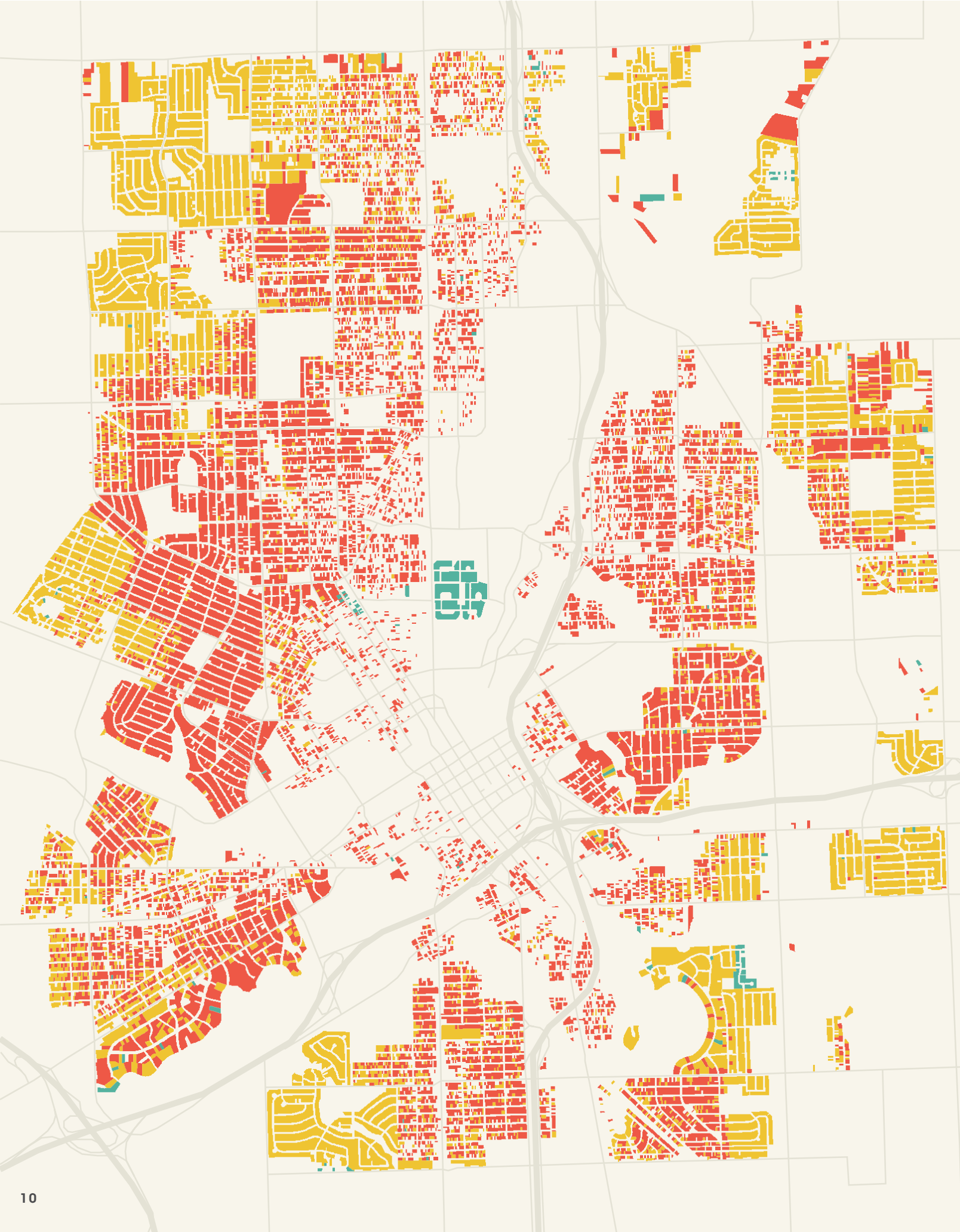
The maps will include shades to indicate ages of pipes as well, broken down by those installed before 1950, between 1950 and 1986, and those that came after. The post-1986 ones can easily be assumed to not have lead because that was the year that using lead in pipes was outlawed.

Taking factors like that into consideration with the parcel maps, Kaufman says that some zones of the city are more likely to have lead pipes than others. These hot spots appear to make a ring around the city's outskirts. Toward the city's center, the problem isn't as common.

"We're still looking at the data, but it's probably correlated with the oldest homes in Flint," said Kaufman. "It makes kind of a ring around the town center on all sides."

Once the project wraps up, Kaufman expects that the maps he and others from the university's Geographic Information Systems Center have generated will prove useful for tackling Flint's water crisis. The approach could also be used in solving drinking water problems encountered by other cities with poor records of where pipes are located.

"All water utilities should try to map all locations of their pipes, including the ones going into homes," said Kaufman. ☐



Map: Fondriest Environmental, based on data from the GIS Center at University of Michigan - Flint

## AGE OF RESIDENTIAL STRUCTURES IN FLINT

- BUILT BEFORE 1950 (23,272 TOTAL)
- BUILT 1951-1986 (15,854 TOTAL)
- BUILT AFTER 1987 (284 TOTAL)

(USING LEAD IN PIPES OUTLAWED IN 1986)

# SIPPO LAKE SEDIMENT QUESTIONS

Stark County Park District managers study how Sippo Lake affects water quality after sediment load reduction efforts and push place-based learning tools.

BY DANIEL KELLY

Sippo Lake in Stark County, Ohio, has long had a sediment problem. Years ago, in the late 1990s, it was so choked full of sediment that its max depth was only about 4 feet.

Because of the extensive silt that had practically filled the lake in, officials with the Stark County Park District opted to have it dredged through 1997 and 1998 and nowadays its depths have much improved. But as for the sediments coming in, that's still an issue that managers are working on.

In a recent visit, the Environmental Monitor got a chance to see how park officials are studying Sippo Lake's sediment issues as well as some of the moves they've made to address them. A big part of the push, in addition to collecting data, depends on involving teachers and students from local high schools and colleges to create place-based learning opportunities that nurture local interest and support of the lake and its surrounding watershed.

"Our hope in the long run is that projects like we're doing here lead to more and more place-based research here locally," said Nick Morris, education department manager at Stark County Park District. "We've got six higher-ed institutions in Stark County and we want them collaborating on research projects as much as possible."

We caught up with Morris and Robert Hamilton, an aquatic ecologist at Kent State University, while the two visited a site at the lake's southern end where it gets a lot of water flowing in. At this site, there are three tile drains, one of which is large enough for someone to crouch through.

## AT THE INFLOW

We had been tipped off before driving to the spot that it'd be easy to see the sediments coming in. And we really weren't disappointed given all the gravel that we saw in the pool beneath the drains. All of the water that flows through creates that, especially during storms, Hamilton says.

"The water comes in with such force and you'll see the bottom there is primarily gravel and fine sand. You can see where it has cut a channel. ... It's digging a hole new channel," said Hamilton. He points out that the pipes do the job that engineers meant them to do in taking runoff from the residences and commercial properties nearby and pushing it away. But unfortunately the big pipes don't really serve the lake's inhabitants as well.

At this inflow, park managers have placed a monitoring station that keeps tabs on the sediment loads pulsing into the lake. Its base is a solar-powered NexSens 3100-iSiC Data Logger, but most of the important readings come from an In-Situ Aqua

“OUR HOPE IN THE LONG RUN IS THAT PROJECTS LIKE WE’RE DOING HERE LEAD TO MORE PLACE-BASED RESEARCH HERE LOCALLY.”

- Nick Morris  
Stark County Park District

Photos: Daniel Kelly / Fondriest Environmental





Robert Hamilton (left) and Nick Morris deploy an In-Situ Aqua TROLL 400 Multi-Parameter Probe (in custom deployment pipe) at an inflow to Sippo Lake.



Newly restored wetland space near Sippo Lake.

TROLL 400 Multi-Parameter Probe deployed at a depth where it will always be submerged.

Its guided and given more stability in that effort by two metal fence posts stamped into the channel. But a custom-built deployment pipe is important here too. It's made of drilled-through PVC, a few screws that make it easy to remove the sonde and a bent nail at the bottom that serves as a stopper to keep the AquaTROLL secure.

"I have innovative construction skills," said Morris, remarking on things that he builds. "They're never built to last but they solve the problem."

From there, the channel doglegs a little to the left before whipping back around and entering Sippo Lake. But before making it out into open water, park managers have another trick up their sleeves. At this inflow, as well as others for the lake, they have installed screens of coconut baffles.

The innovative idea is that the baffles help to catch sediment heading toward Sippo Lake. Then, as the baffles decompose, they create new areas to support the growth of aquatic plants that can cut through the sediment loads on their own in the future.

The success of the move is yet to be seen, and Morris tells us that he and others plan to revisit it in the near future. But it lines up well with the goal of alleviating and tracking the sediment loads that make it into the lake.

"What we're trying to do with this data is figure out what the water is like when it comes into the lake and then we have our other monitor is set up just on the other side of that picnic shelter and

play area in an outlet stream," said Morris. "So what we're trying to see is what does the water look like when it comes in and what does it look like when it goes out and be able to kind of tell is our lake serving its purpose for protecting the watershed, taking care of sediments and other things."

Some of the preliminary data collected so far point to there being some major issues, Morris says. And some really important things are happening ecologically. But it seems so far that the lake is doing a good job of improving water quality.

## RESTORED WETLAND

But there's of course more than one side to Sippo Lake and each one has different things going on.

The site we'd just visited was on the southern end. At the lake's north is where the main park buildings are. And on the eastern side, there is a tiny inlet that doesn't contribute anything to the lake unless there's a lot of rainfall.

The lake's western side, however, is home to a recently restored wetland that plays a big role in Sippo Lake's sediment woes.

A little less than a year ago, park managers worked to re-route water pulsing through a tile drain back to where it needed to go. It was being diverted down a ditch and away from the wetland, which had starved the 13-acre space over time of the flows it needed to survive.

About 900 cubic yards of dirt was excavated out of the center of the wetland. Ten-thousand native plant plugs were put in, and numerous invasive plants were pulled out, the likes of reed canary grass, buckthorn and garlic mustard. And then a new

structure was put in near the drain that made it so the water goes to the wetland first and then to the lake.

At this spot, Hamilton regularly checks the water for pH, dissolved oxygen, nitrates, phosphates, conductivity, temperature, salinity and oxidation-reduction potential. The idea is ultimately to see how the wetland is impacting water quality.

"You can read any book and it will say road runoff contains X, Y, Z. Wetlands should clean it," said Hamilton. "But what's really happening right here? I mean I live five minutes that way so this is what's happening in my neighborhood."

Going along with that sentiment, the wetland site has become increasingly important for supporting the place-based thinking that park managers are trying to encourage for members of the surrounding communities. Some 30 teachers from nearby institutions have already toured it to learn how they can include what they saw in their lessons.

Morris says that he wants students, as well as many teachers and locals, to start thinking about watersheds like communities, instead of in terms of school districts or neighborhoods. His preference would be for folks to consider what natural communities there are and see that important things like water don't really care where we live.

"It travels between very wealthy subdivisions and very impoverished urban communities and very industrial areas and then very rural farm areas. It's water," said Morris. "So something that is so central to our existence really transcends any sort of boundary that we try to create for it. If we can have students start thinking about their natural communities, their own personal identity and role within their community can change as well."

Photos: Daniel Kelly / Fondriest Environmental


## MOVING FORWARD

In the future, perhaps after about a year's worth of data has been gathered at Sippo Lake's southern end, park managers may move the station to the wetland so that they can continually capture what the water quality is before it enters. This would allow them to figure out exactly what effects the restoration project has had. But in the more immediate future, there are plans for expansion.

"We have a partnership with our local education service center which serves all of the county schools. We are doing a water quality teacher training that we've been doing throughout this year, so they're looking at how to use this data for unit development, course development, in their schools, with middle school and high school kids," said Morris.

Officials at the service center are planning to put in another two monitoring stations at locations elsewhere in the county. And then the teachers will have access to data from all of the stations to use in their classrooms.

Those two new stations will likely go toward the northeast corner of the county, near the Mahoning River drainage. It's an area dominated by rural and agricultural lands and drains differently than the watershed around Sippo Lake.

"We can teach students that agriculture leads to X, Y and Z. What we want our students doing is knowing what our agriculture is," said Morris. "We want our students knowing that when it rains here, this is what happens, not just when it rains in a watershed this is what happens. We want them to be very place-based and really think about what water does in Stark County." 

# BUILT TO HANDLE THE TOUGHEST PROJECTS

NEXSENS CB-SERIES DATA BUOYS  
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NexSens CB-Series Data Buoys are designed for deployment in lakes, rivers, coastal waters, harbors, estuaries and other freshwater or marine environments. The floating platform supports both topside and subsurface environmental monitoring sensors including weather stations, wave sensors, thermistor strings, multi-parameter sondes, Doppler current profilers and other monitoring instruments.

The buoys are constructed of an inner core of cross-linked polyethylene foam with a tough polyurea skin. A topside stainless steel tower includes three solar panels, and a center 10" ID data well accommodates batteries, data loggers, sensors and more. Three pass-through holes with female NPT bottom threads allow for quick connection of instrument deployment pipes and custom sensor mounts. The stainless steel frame supports both single-point and multi-point moorings.



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## PME Cyclops-7 Logger

Providing single-parameter data and an alternative to purchasing expensive sondes.

BY DANIEL KELLY



Multi-parameter water quality sondes are amazing for monitoring the health of lakes or rivers when they're mounted on buoys. But sometimes a research project doesn't need all that data, or the cost that goes with it. Fortunately there is an option for those looking to gather high-quality data of just one measurement while saving on the expense of a sonde: the PME Cyclops-7 Logger.

The logger fills that need and is the only product out there, as far as we can tell, that offers such a single-parameter logger system for researchers to use.

"The PME Cyclops-7 Logger provides a platform for researchers to capture high-frequency (1-minute interval) data in a self-contained, small-diameter package," said Kristin Elliott, chief executive officer at PME. "The PME logger has a depth rating of 100 meters and can be deployed for long periods of time. It is easy to set up and retrieve the data once the deployment is over."

Its developers worked closely with Turner Designs to come up with a solution for the pros out there looking for a logger that could be used with individual Turner Designs Cyclops-7 sensors. In addition to that, the logger's size is compact enough that it can be used in borehole applications and is fully submersible for added flexibility.

That is largely achieved by its construction, with all internal components like C-Cell batteries, memory card (28,800-sample capacity) and circuit board housed within a rugged Delrin body

that is toughened against cracking or breaking. To protect the Turner Designs sensors, PME has also added a probe guard that keeps them secure while still letting in enough water for accurate data collection.

Elliott says that researchers commonly use the logger in applications like wastewater monitoring, tracking contaminants or in cleanup operations like those following oil spills. Some of the common parameters that technicians monitor include measurements of algal pigments, dyes, fluorescent dissolved organic matter and turbidity.

"There are currently thirteen different standard Cyclops (sensor) configurations available," said Elliott. "Custom optics are available for non-standard applications."

Following data collection, downloading measurements from the Cyclops-7 Logger is a snap with a Java-based software program supplied to each user. Each recorded sample includes the sensor measurement, time, date and logger battery voltage.

The software also supports visual data plots and sensor calibrations, which comprise the main maintenance concern, says Elliott.

"The Cyclops-7 and PME Logger are both Solid State devices and very little maintenance is required," said Elliott. "The Cyclops-7 should be rinsed with fresh water after a deployment and any biofouling can be removed with a soft cloth."

# LIBERTY ISLAND RESTORATION

U.S. Geological Survey scientists use a network of monitors, aided by a NexSens CB-950 Data Buoy, to gauge the Liberty Island Restoration Project's success.

BY DANIEL KELLY



Researchers deploy a NexSens CB-950 Data Buoy near Liberty Island in the California Delta. The buoy's sensor package includes a YSI EXO water quality sonde.

The Liberty Island Restoration Project was an ambitious undertaking to bring back part of the California Delta's wetlands and habitat. The damage to the wetlands that were once present there had persisted for so long that officials working on the project had to bring in historians just to figure out where the old marshes used to be.

That was around 2010, during which year a design for the project was completed and implemented. It created open water channels, emergent tidal marsh lands and floodplain habitats to sustain water fluctuations. All of this was done in an effort to help important wildlife living in the delta as well as fish species like Chinook salmon and delta smelt.

But beyond just putting new marshes in place, it's important for delta restoration managers to verify that their efforts made a difference. Doing that involves monitoring conditions around the site to see how its habitats and water quality have improved.

Crews at the U.S. Geological Survey's California Water Science Center oversee such a network that encompasses the delta. It relies on a number of continuous monitoring stations that gather data on the area's water quality, and has been collecting data for the last few years. In 2014, the USGS added a NexSens CB-950 Data Buoy to complement that effort.

"The buoy is located at the mouth of Liberty Island in the Cache Slough Complex in the northern portion of the Sacramento-San Joaquin Delta," said Scott Nagel, hydrologic technician with the U.S. Geological Survey. It is equipped with several sensors measuring parameters including water temperature, conductivity,


pH, dissolved oxygen, turbidity, fluorescent dissolved organic matter and chlorophyll-a.

Nagel adds that nitrate, phosphate, ammonium and blue-green algae are also tracked. "All parameters matter, but the nutrient parameters can really help us to understand the lower trophic food web and bottom-up drivers of the aquatic ecosystem," said Nagel.

There is a small crew, he says, that maintains the water quality continuous monitoring network at the USGS. These include Thomas Johnston, student intern; Renee Runyon, hydrologic technician; and Kyle Nakatsuka, a field assistant.

Other buoys in the network, two NexSens CB-500s, help to add to the understanding of the impacts that conditions and nutrients have on aquatic life in the delta and the overall quality of their habitats. Too much turbidity, for example, could influence light penetration in the water that aquatic plants use. Or high algae levels can bring about low-oxygen conditions for fish.

But data aren't just upping knowledge for folks at the USGS. Nagel says that the data gathered are also shared with concerned stakeholders and make their way into print for wider distribution. The data from the buoy are sampled every 15 minutes and telemetered.

"We have had a buoy at this site for almost three years and have been constantly pleased at the data quality," said Nagel. "Some results are currently in press and others are being compiled into a data report, so keep an eye out for them." 

All Photos: Scott Nagel / U.S. Geological Survey California Water Science Center



# EYES ON OHIO STREAMS

Photo: Daniel Kelly / Fondliest Environmental

Photo: Laura Johnson / National Center for Water Quality Research

The Environmental Monitor recently visited the National Center for Water Quality Research (NCWQR) at Heidelberg University. Here's what we learned.

BY DANIEL KELLY

What started as a simple biology project for a class at Heidelberg University is today the National Center for Water Quality Research (NCWQR). It's a beautiful example of how far small actions of the past can ripple into the future.

"It was actually an outgrowth of an educational drive," said Ellen Ewing, laboratory manager at the NCWQR who was working at the Center at its beginning. "Dave Baker, who is our director emeritus, was a professor here at Heidelberg and he wanted to introduce some new concepts to the introductory biology classes. And so he put together a program for a National Science Foundation grant and started with some sample collection on the Sandusky River."

We caught up with Ewing and Jake Boehler, a research assistant at the Center, on a recent visit to Heidelberg University in Tiffin, Ohio. The two are part of the team that goes out every week throughout the year to gather water samples collected by automated monitoring stations on many of Ohio's waterways, helping to assess their nutrient loads, which affect water quality downstream and, for one of the stations, forms the basis of Lake Erie algal bloom forecasting.

The purpose of the biology project that started it all, Ewing says, was to introduce inexperienced biology students to the processes of sampling. It focused on the Sandusky River and incorporated taking water samples from the river and then analyzing them in a series of lab experiments focused on bacteria, phosphorus and nitrogen loads.

That first project generated a lot of interest into the issue of tributary nutrient loads, Ewing says. And from there, more advanced summer research projects, driven by undergraduate students, would follow. Slowly but surely, the projects began to yield interesting and useful data that would become the foundation of important discoveries, including one on the influences that different flow regimes have on the movement of nutrients to Lake Erie.

"In 1969, this area sustained a 100-year flood and the student project that was written up was to study the Sandusky (River) during low flow. Well, in a 100-year flood, you kind of don't have low flow. So, like all good researchers, they persevered and started to generate some interesting numbers," said Ewing. "About that time, the federal agencies were getting involved. Lake Erie was dead, all those kinds of scenarios — the Cuyahoga River caught on fire. And so what Dr. Baker (David Baker, director emeritus and founder of the NCWQR) discovered — and his actual PhD background was in transport systems in plants and he sort of transplanted that to transport systems in rivers — and realized that about 90 percent of what's delivered down our rivers happens during about 10 percent of the year, on average, during high flow."



Sampling bottles from a stream monitoring site.

From there, the NCWQR and its staff would begin to specialize in monitoring the transport of nutrients through streams. And a rich history would start to take shape, one resulting in what researchers all around the Great Lakes know and value as the Heidelberg Tributary Loading Program, an incredibly useful tool in the fight to fix the current Lake Erie algal bloom problem.

But that is not all that the Center's staff work toward. There are many other initiatives they support, including the Cooperative Private Well Testing Program that provides low-cost water quality tests for anyone in the United States with a well. The Center also runs a website, lakeeriealgae.com, to educate people about the issues faced there and what's being done. Other works include studies looking at the health of macroinvertebrate communities in Ohio streams and Lake Erie, as well as large efforts to model watersheds throughout the state to determine different methods that farmers can take to clean up runoff flowing off their lands.

## STREAM MONITORING

During our visit to the NCWQR, we had a chance to tour a sampling station located on Rock Creek, which flows right by the university. From there, we got a behind-the-scenes look into how all the samples moving through the Center get analyzed.

The Rock Creek station is much like the many other stations that the Center helps to manage throughout the state of Ohio. According to the most recent total, there were 18 stations in all, with one located in Michigan.

And not all are created equal: Some are bigger or smaller than others, including the tiniest site, which sits on an unnamed tributary of Lost Creek near Farmer, Ohio.



Jake Boehler services an automated sampler.

"Just a little, tiny creek they put a little weir in to be able to get flow measurements that we need to go with the concentrations that we get," said Boehler. "And this one is slightly special in that we have two samplers set up in here so that the data logger, when the stage gets above 1.75 (feet), it trips this sampler to kick on and it takes samples every two hours. So when it's really raining, we get more samples."

As Boehler describes the setup at the Rock Creek station, he notes that many of the others in the network are set up the same way, with ISCO automatic samplers at their core. Within each, there are plates to hold plastic sampling bottles. As a water tube spins around, bottles get filled up one by one.

"So that's where we are now. Back in the day, students collected samples with a bucket and a bottle and we lowered it down from a bridge," said Ewing. "(They) brought it back to the lab, we did manual chemistries where everything was colorimetrically analyzed but it was all done by hand." That type of processing began to change in 1974, she says, when work in the lab began to be automated with the help of machines like colorimetric analyzers and ion chromatographs.

Of course, before the samples can be analyzed, they have to be collected. That's where Boehler and Ewing, who makes sampling runs with Research Assistant Barbara Merryfield, focus a lot of their efforts. And there isn't a break — they are out collecting samples no matter the season or the weather.

Boehler's route, like the other, is every Monday. Gathering samples essentially involves driving to a station and swapping a new, empty base of bottles into a sampler and retrieving the base containing the previous week's samples. The two routes cover the stations within reach, but there are two sites that rely

## “BACK IN THE DAY, STUDENTS COLLECTED SAMPLES WITH A BUCKET AND A BOTTLE AND WE LOWERED IT DOWN FROM A BRIDGE.”

- Ellen Ewing  
Laboratory manager at NCWQR

on the help of volunteers who gather samples every day and send them in. Unlike the automated collection at most sites, the work in these streams is done using old-fashioned buckets lowered off of bridges.

"The Cuyahoga, Muskingum, Scioto and Great Miami (Rivers) are all that same way where someone actually goes to our site, whether it be grabbing a sample with a bucket or automatically like one of our stations and they just ship them to us then in coolers," said Boehler.

The volunteer who helps out on the Muskingum River has been doing it since the 1990s and takes the duties seriously. He has gotten into his eighties, but sends in samples reliably for the Center.

"He was very apologetic because he had to miss a little bit because he had a knee replacement," said Ewing. "And even then he had his wife go out and do it for him."

But similar care goes into processing all the samples, as well as keeping stringent quality control checks to ensure that the data produced are accurate and useful.

"If you read any protocol for doing dissolved reactive phosphorus, you're supposed to analyze it within 48 hours. That's impossible to do and do the type of intensive sampling that we do," said Ewing. "So within the base, there's this special bottle (that we leave). And so bottle No. 24 and bottle 'SX10' are going to be filled at the same time on Monday. Bottle No. 24 is going to come back here and be analyzed immediately or within 48 hours. That SX(10) bottle in the middle is going to stay out there for a week. And we will then compare the values we got for the fresh sample versus the values that we got for the stored sample so that we can then back up the quality control on our data and try to assuage some of those people who tell us that we can't do this because we're beating, or exceeding, holding time."

### DATA ANALYSIS

Back in the lab, analyzing samples is such a big job requiring so many machines that viewing the processes to someone unfamiliar (certainly us that day) is like taking a tour of a fast-moving industrial factory. But instead of the crew you'd expect, all the workers are well-trained scientists and produce data instead of goods.

Walking through the third-floor lab housed in Gillmor Science Hall on Heidelberg's campus, there are big machines and small machines. Contraptions on long tables feature circulating glass



A staff gauge tracks Tiffin, Ohio's Rock Creek's water levels.

tubes, filled with liquids colored blue (for total phosphorus) and orange (for total Kjeldahl nitrogen). Some rooms are filled with sampling bottles, while others hold more machines. These are used for the tributary monitoring program while others support the well testing program.

Common equipment includes colorimetric analyzers, ion chromatographs, filters and balances for weighing, which we're told was one of the first things to get automated in the lab.

"We literally send the weight into a program that takes care of keeping track of all of that information in addition to sample location, sample bottle, volume filtered and all of the assorted pieces of information that we need for this," says Ewing. Thousands of weighings are done each year, she says, given the magnitude of the sampling operation.

One of the machines used is a Seal AA3 analysis system. It evaluates ammonia, dissolved reactive phosphorus and silica. From there, we moved on to a large area dominated by ion chromatographs where Merryfield demonstrated a typical sample run.

"The idea behind this is we have our sample. It's been prepared in whatever fashion it needs to be prepared, and we then add sample and reagent," said Ewing, pointing out the spinning glass coils pushing through colorful blue and orange. "Wherever there's a fitting, there's either a reagent or sample that comes into the system. The glass coils, you can see them still tumbling, because this was actually finishing running. That's acting as a mixing chamber and so the idea here is that we have the two meet, mix, may heat it may not, depending on the chemistry."

From that point, scientists take a look at the color that is produced. The darker the color, or the more intense that a color

is, the higher the concentration. Merryfield shows us on a computer screen how one of the peaks in a line graph is edging upward. The peak moves higher, indicating the strength of the concentration. This process is repeated for hundreds of samples, Ewing says.

"The idea behind these chemistries is steady state. So we add reagent and mix until we get no further color production," said Ewing. "So this is a very classic peak. You want to see that peak flatten off and maintain."

We venture down the hall to a solutions prep room and from there to a trace metals room containing a big, boxy machine called an Inductively Coupled Plasma Mass Spectrometer. It is an important piece of equipment for the well testing program, which has processed more than 90,000 samples for private well owners around the United States over the years.

"In the late '80s, we started a well-testing program through funding with the (Ohio) Farm Bureau where they actually would, basically, pay most of the cost for people around the area and turned it into the whole statewide program," said Boehler. "And now I think we've done 37 or more states, well samples from different states where they send us a sample and we process them for metals and these are things like arsenic, calcium, magnesium, things you can use to figure out your water hardness." The total number of metals they screen for is about 20.

The program has yielded some useful information for well owners. Roughly 10 percent of the wells that come through the program have been found to have some sort of structural deficit. What that means, typically, is that problems people find with their wells, and water, are due to poor construction or the integrity of the well's structure. Examples of this include ruptured casing

Photo: Laura Johnson / National Center for Water Quality Research

Photo: Daniel Kelly / Fondriest Environmental



Rock Creek stream monitoring station.

from a lightning strike, or fractured bedrock nearby that lets surface water penetrate.

In addition to the regular chemistries on the well water, the Heidelberg crew also does a couple pesticide screens. These cover the water-soluble forms that are most commonly used today, like atrazine and alachlor.

#### HOW DATA ARE USED

Data from the Heidelberg tributary monitoring network are used in a lot of ways. They have been a primary source of conclusions drawn by researchers studying Lake Erie's western basin and its algal blooms for some time, but that is not the only purpose they serve.

For insight into some of the ways that all the findings get used, we talked with Ken Krieger and Laura Johnson. Krieger has recently retired as the Center's director and Johnson has assumed the role beginning in 2016.

Our conversation was wide-ranging and not altogether linear, but we learned about prominent trends reflected in datasets collected by the Center over the course of the previous year. And we dug into some of the implications the numbers have for the years ahead as well as continued monitoring in the Great Lakes region.

"We've found lots of things in our long-term dataset. The biggest finding has been that dissolved phosphorus, dissolved reactive phosphorus, has been increasing pretty drastically since the mid '90s. It's increased and then it's sort of leveled off," said Johnson. "And because we see them in the Maumee River, which is one of the main inputs into Lake Erie, we're attributing

that increase to the recurrence of algal blooms that we've been seeing since about 2003."

There are nuances there, Johnson says, and notes that most of the metrics that they show are reported on an annual basis, including yearly loads and concentrations. But when trying to relate the size of the blooms that are seen in Lake Erie to what's coming out of the Maumee River, the most important time of year to focus on is the spring.

More specifically, nutrients that make it into the lake from the beginning of March through the end of July seem to have the most impact on the size of the algal blooms. This knowledge has helped scientists at the Center to contribute to a forecasting system, which was created by the National Oceanic and Atmospheric Administration, for the size of the bloom each summer.

Timing is important for that, but so are the nutrient loads. And when it comes to dissecting those, you can parse them out in different ways. Those from point sources have not gone up to coincide with the recent return of algal blooms from the mid-1990s, while non-point sources seem high depending on the year that you look at.

"Sometimes they're more equivalent, but what you're really missing when we look at total phosphorus is we don't have a good explanation for why algal blooms have returned," said Johnson. "And so it's not until you actually look at the dissolved phosphorus component."

There is a downward trend in particulate phosphorus, Johnson says, while there is an increasing one for dissolved phosphorus and that makes total phosphorus appear to have little change. Still, only a little more than 20 percent of total phosphorus is

## “ THE BIGGEST FINDING HAS BEEN THAT DISSOLVED PHOSPHORUS... HAS BEEN INCREASING PRETTY DRASTICALLY SINCE THE MID '90S.”

- Laura Johnson  
NCWQR Director

dissolved, while the rest is mostly particulates that algae can't use. Much of that settles out before it can make it to Lake Erie anyway, so the details of all the figures are important in knowing what factors are at play in algal blooms.

"Our founders decided to measure dissolved phosphorus even though the water quality measure for phosphorus is usually total phosphorus," said Johnson. "They added that in since the very beginning. It's always been there."

But what about nitrates? That's been monitored by scientists at the NCWQR from its beginning too. Krieger tells us that nitrates coming from the watersheds they monitor in, particularly agricultural ones, are down from what they were in the early 2000s.

"There was a general increase until about 2000, 2002, and since then, there's been a general decline," said Johnson. The average for the Maumee River has gone from 7 milligrams per liter in 2001 down to 4.5 milligrams per liter in 2014. And that's not huge, but it is substantial. "They're (farmers) getting higher yields because of new varieties of corn and, which is what they needed nitrogen for, and they're more efficiently using nitrogen. So they're not applying that much more but they're getting a lot more yield, and so it seems like there's a possibility we're seeing this response in terms of nitrogen just in advances in crop technology."

For all rivers across the state with agricultural land use, there is a reliable period on which to bet that a nitrate surge will appear in the data and that is right around the planting season's first big rain event. In that way, nitrate spikes can almost be used as a tracer for agricultural activity.

Other researchers are studying nitrogen's role in the toxicity of algal blooms. The decreasing trends that the Center's data show may very well support the idea that there's more to it than just nitrogen. It's well established that phosphorus drives the size of the blooms, Johnson says. And so toxicity isn't something that could solely be associated with nitrogen loads, but the levels are high enough that they could influence toxicity. The concentrations could also have effects on the future composition of algal species in Lake Erie.

"If nitrate keeps going down and phosphorus keeps staying up, that might have a big effect on what we see in the future," said Johnson.

Beyond nitrogen and phosphorus, a lot of work is done to monitor suspended sediments in tributaries. These efforts date



Sandusky River.

back to a time prior to the second phase of the Great Lakes Water Quality Agreement wherein farmers and land managers were trying to turn soil over less often, put in buffer strips and promote conservation tillage as ways to reduce the sediments that made it into Lake Erie.

The idea for those actions was also benefited by the fact that they would probably help to reduce the loss of particulate phosphorus, which they did. Seeing the patterns is a little more difficult, Krieger says. But he notes that the quantity of water that's flowing through rivers like the Maumee and the Sandusky has increased quite a bit since the 2000s and there are much higher average flows than there were back in the 1980s.

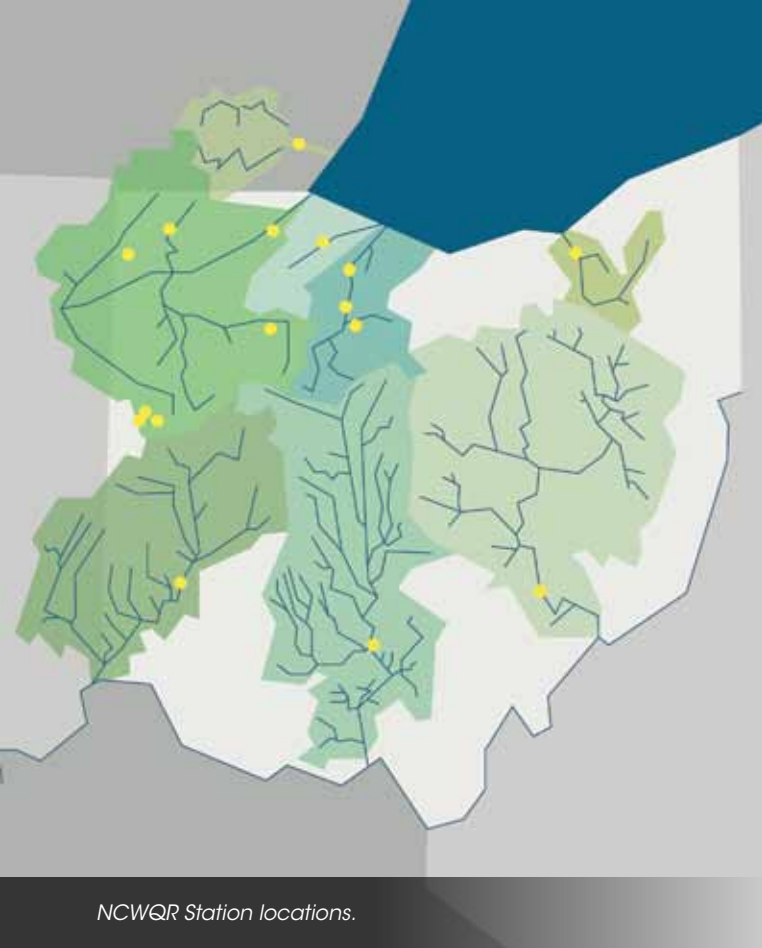
So if you're considering something like suspended sediments or particulate phosphorus, the erosive capacity of rain events can push those higher. But add in the effects of good management practices, and something else comes to light: There can still be high flows that push sediment concentrations higher, but those concentrations are still lower than they were for a similar flow event back in the 1980s.

"But then we see something else in terms of dissolved phosphorus. Everywhere we look (in agricultural watersheds), the dissolved phosphorus has gone up," said Krieger. "The proportion of dissolved phosphorus to all the phosphorus, what we call total phosphorus, has increased." These changes have come about since 1995, and they're owed to changes in the sizes of farms, how fertilizer gets applied and increases to the intensity of precipitation in the area.

And there are still other things that the Center's staff have tracked over the decades. One you might not expect is silica, something that we confused with sand.

Photo: Daniel Kelly / Fondriest Environmental

Photo: Laura Johnson / National Center for Water Quality Research



NCWQR Station locations.

"Silica is a component of sand, at least the type of sand in non-volcanic regions," said Krieger. "And so it's a component of glass and diatoms basically have glass shells, which is what makes them heavy and they tend to sink."

But why would you want to monitor something like that? Well, think back to the decision to track dissolved reactive phosphorus even though it wasn't a typical thing to track. There is always a good reason for collecting data, or at least a good scientist can give you one.

"Of course the diatoms are taking all that (silica) up," said Krieger. This is because they use it to form their shells. He adds that diatoms grow like crazy in colder temperatures and cites a Bowling Green State University study that is looking into how they behave in the winter. "They have to be playing a big role in the dead zone in the central basin because they're going to settle out, go to the bottom and decay just like the bloomers, cyanobacteria, do too. So there's a winter, maybe fall through spring, component of the algal cycle nobody's really paying much attention to which is not causing a problem in the western part of the lake but might be causing part of the big problem in the central basin. There's just a lot of dynamics going on."

The insights that researchers at the Center have gained over the years are considerable. And all of them are proof of the worth of their efforts and the tributary loading network because there's no way that one or two stations would provide all the information resource managers need to know.

"We get the question: 'Why do you need to keep monitoring year after year? You've done this for 30 years already,'" said Krieger. "Well, it's because we've done it for 30 years that we can see these things."

## WATERSHED MODELING

So far, we've talked about a lot of data collection. But an important question is how the data actually get used in attempting to solve the problems that they help to quantify.

To get some insight into that side of things, we talked with Rem Confesor, senior research scientist at the National Center for Water Quality Research who is heading up efforts to model the hydrology of watersheds that impact water quality in Lake Erie. In addition, he is working with other modelers around the state to launch a new program to compensate farmers for the nutrient runoff reductions they achieve.

Confesor's work applies much of the understanding that the Center has gained over the years in a modeling approach to make improvements in the real world.

"We're basically trying to understand the problem, trying to understand the processes for what causes the problem. So the purpose of the modeling actually is, given all the limited understanding of the problem, what can we do?" said Confesor. "So this is the solution side really, so we're not just identifying the problem and just analyzing the trends or the cause but I think my task is to test implementing the solutions at this time with the limited knowledge that we have."

What most watershed models do is take into account conditions like terrain, slope and elevations along with those relating to properties of the soil throughout the region being considered. So things like soil type, depth, its chemical properties and its bulk density (soil weight in a given volume key to its ability to support root growth) get plugged in.

Weather is another important consideration, as the model can't really move without it. Inputs like falling rain and snow are forces that drive the model's behavior, Confesor says. The movements of nutrients like phosphorus are impacted by those flows, as well as other things like crop cover. From there, things get even more detailed.

"It can actually identify if it's urban or if it's forested and if it's agriculture," said Confesor. "If it's agriculture, it can ... identify if it's corn, soybean or wheat." For each crop, the model considers the cover, when it is planted each year and the different agricultural practices used in the process.

As an example of modeling capability, Confesor pulls up the Nutrient Tracking Tool online, a computer program developed by scientists at Tarleton State University and in part by the U.S. Department of Agriculture's Natural Resources Conservation Service. It is a useful platform for farmers who want to consider changing up their farming practices to get different results. What's great about it is that it can zero in on specific land parcels across the country. Just enter an address and you're ready to go.

From that point, users can enter the sort of treatments that they currently apply to their lands, like choice of fertilizer, the crops planted and land management approaches used, like crop rotation. And then it's possible to consider what might happen if they adjusted things by inputting that info too.



Stream monitoring station.

"For example, this is your actual fertilizer, or tillage management system. So you just don't plow, you don't apply fertilizer," said Confesor, pointing out fillable information boxes in the tracking tool. "This is a type of planter or something like that. And then you plow again for soybeans (as an example). So you're using conventional tillage. And what if you copied that alternative but this time changed it so there's no tillage? So what's going to be the difference?"

Though using the tool can be difficult for some, Confesor says that it at least provides an easy way to compare the effects of different approaches, like tilling or not tilling.

But looking at actions taken at the field scale is fairly simple when compared to considering those over a larger land surface, such as an entire watershed. So that is where most of the difficulties come in, like accounting for activities of all the tiny farms existing in a much bigger region.


"So that's the main problem with scaling up from the field scale to the watershed scale," said Confesor. "It's still the challenge of what's going on in between the small farms as it flows to the outlet of the watershed."

But the end goal, of course, is better management approaches that can help land managers while also helping farmers who are growing food for all of us on limited budgets. Toward that end, Confesor is working on a project that would push a pay-for-performance approach that could reduce nutrient runoff while keeping farmers' crop yields steady.

He is working with an international nonprofit and local soil and water conservation districts to set up the new kind of program.

"For example, instead of the government subsidizing the farm as to implement the BMP (best management practice), it's not sustainable because if the money's gone the farmers will not stick to it. That's always the case," said Confesor. "So what we do is that for several farmers in a small watershed, we can identify, using the help of the soil and water conservation district people, a small watershed and identify the farmers and ask them to participate in that program where we will use this field-scale model to calculate what's going on in their farm."

The next move is to set up an alternative management scenario that the farmers could use on their land. One key, though, is that farmers would keep the freedom to choose how they want to implement the best management practice. Once the BMP is put in place, Confesor and others can rely on edge-of-field monitoring devices, in-stream samplers and modeling to assess how well each practice is doing.

"We will just estimate with the model the reduction. So based from that reduction in pollutants and the actual year of the farm, we will have some kind of a rule or calculations that we would pay the farmer, whatever the reduction is," said Confesor. "And the more reduction we have, it could be possible that they have reduced the exports and they have at the same time increased their yield — we're still going to pay them. It's based on their performance actually, not on what the government tells them to do. And I think that's what they want." 

Map: Nate Christopher / Fondriest Environmental

Photo: Jakob Boehler / National Center for Water Quality Research

# ALGAE

## A NATIONAL PROBLEM

The first-ever National Lakes Assessment uncovers cyanotoxins in freshwaters across the United States, underscoring the issue's national reach.

BY DANIEL KELLY

When it comes to harmful algal blooms (HABs) in our nation's lakes, much of the focus gets placed on Lake Erie. And though it's an important water body for sure, it is not the only freshwater lake in the United States. Results of the National Lakes Assessment (NLA), a first-of-its-kind survey, have just been released detailing that many of the freshwater lakes in the U.S. also have an algae problem.

The assessment, which began data collection in 2007, is part of the U.S. Environmental Protection Agency's (EPA) National Aquatic Resource Surveys. Those are collaborative programs between the EPA and states and tribes that are designed to assess the quality of waters throughout the United States, be they lakes, rivers, streams, wetlands or coastal regions.

Findings of the NLA cover a huge range of issues and reveal conditions that may help in managing freshwater resources in the future. Its investigators looked at nutrient loads, habitat, contaminants in fish tissues and trophic conditions, among other things. Full results of the effort are detailed in an EPA report.

On the algae front, researchers looked at common cyanotoxins produced by blue-green algae, also known as cyanobacteria, as part of the sampling effort that visited 1,161 lakes across the United States. Each lake was at least 4 hectares in area, or somewhere close to 10 square acres. EPA experts were joined by scientists at the U.S. Geological Survey (USGS) in the effort, employing a number of tools and techniques to get it done.

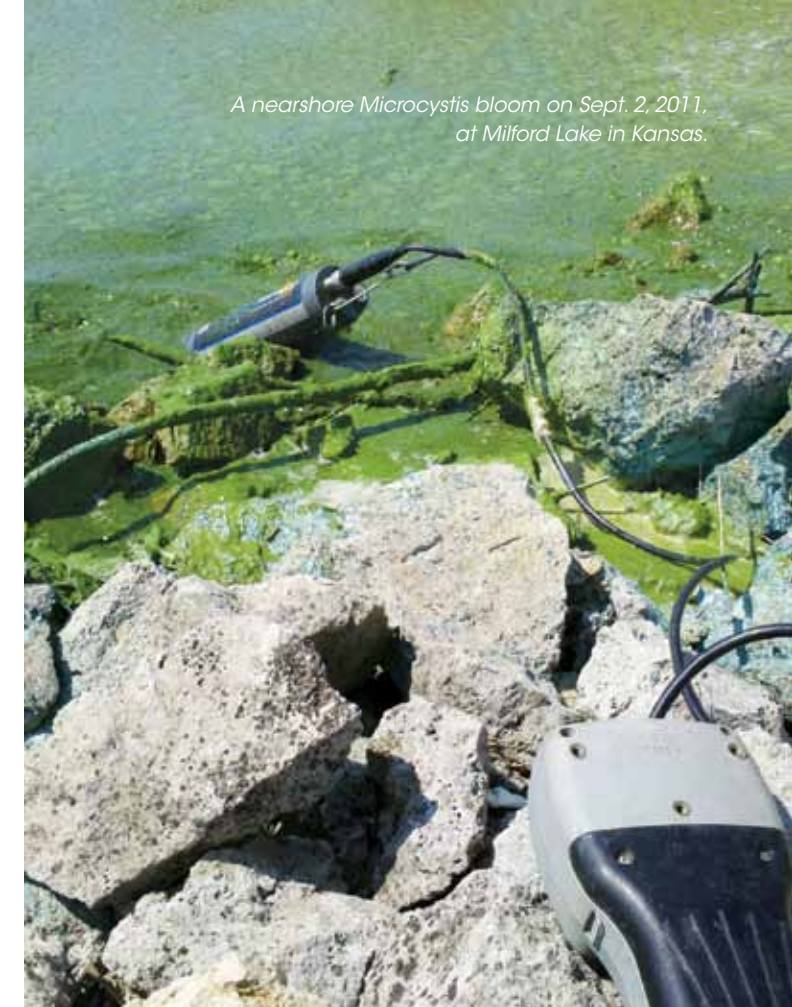
"The toxin assessment was a small piece of the entire study. Cyanobacteria and their toxins were used as a recreational human health indicator," said Keith Loftin, research chemist with the USGS' Kansas Water Science Center. He notes that cyanotoxins have been tied to illnesses and deaths of livestock and companion animals in the U.S.

Lakes were surveyed through ELISA (enzyme-linked immunosorbent assay) analysis of integrated photic zone samples. The ELISA approach is a less expensive screening tool than others while allowing for more simultaneous sample analysis. Multiparameter sondes were also deployed to give researchers snapshots of water quality onsite.

"Secchi depth was used to determine the photic zone for sampling near the center of a lake," said Loftin. "Samples collected near the center of the lake would be considered to represent more of an ambient sampling versus a worst case type of sample. Blooms tend to concentrate near shore but even at the center of the lakes, we found a 32 percent detection frequency of microcystins which is higher than we expected in the center of the lakes."

Microcystins are the toxins that made drinking water unsafe for half a million residents of Toledo, Ohio, in 2014. That disaster may have contributed to more focus on the toxin as many studies

A nearshore *Microcystis* bloom on Sept. 2, 2011, at Milford Lake in Kansas.



looked for the presence of microcystin as an indicator that other toxins like cylindrospermopsins and saxitoxins were present.

Loftin and others found detection frequencies of cylindrospermopsins in 4 percent of samples. For saxitoxins, that figure was 7.7 percent. But there really was no relationship between microcystin levels and the presence of either of the other two classes of toxins. Cylindrospermopsins were found alongside microcystins in 0.96 percent of samples and saxitoxins were found alongside microcystins in 5.0 percent of samples. All three classes of toxins were found together in just 0.32 percent of samples.

Because of the time considerations and the fact that scientists visited each lake typically once, it's not really possible to say that any of the water bodies sampled in the National Lakes Assessment are in great shape or poor shape with respect to future cyanotoxin production, Loftin says.

"We don't yet know why these toxins are produced," said Loftin. "The HAB problem has a temporal and spatial nature to it that is very dynamic. Our data look at one point in time, so a label like that can be misleading on a single-lake basis."

He says he has encouraged folks to take what they've learned through investigations in the Great Lakes and apply it elsewhere to better manage freshwater resources across the country.


"The problem is national and we need to do more work to understand HABs and their adverse impacts. Are there steps we can take to keep HABs from getting worse?" said Loftin. "Basically, how can we live in this world and better manage this issue for more effective resource utilization?" 

Photo: (left) Lindsey King; (right) Eric Looper / U.S. Geological Survey



# OCEAN CURRENTS

New findings on small-scale turbulence deep in the Gulf of Mexico aid understanding of ocean currents, with implications for weather and climate models.

BY DANIEL KELLY



We don't know as much about the oceans as we'd like to. In fact, many scientists studying in the salty seas that we have on our planet would call us desperately data poor. Of the ocean instrument arrays that are deployed today, the oldest are only about 25 years old. That's not long in terms of Earth's history for recording trends.

And even though we do have some idea of how the oceans heat up and cool down, or how the weather patterns that rise off them work, including El Niño and La Niña, there is still much left to discover. Even knowledge of the movements that ocean currents make is something that still eludes us.

One study authored by researchers at Stanford University details one effort that has shed a little more light on one ocean current, the meridional overturning circulation, a global conveyor belt of water that carries cool surface waters along equatorial regions where they mix with warmer waters and rise to the surface.

In these areas, the question of turbulence is an important one to answer in determining how currents behave. And rough topography typically produces a lot of small-scale turbulence. But the investigation, led by Ryan Holmes, at the time a graduate student at Stanford's School of Earth, Energy & Environmental Science, found that the small amounts of turbulence were still

present even if there was no rough sea bottom around. Holmes is now a doctoral student at Australia's University of New South Wales.

The investigation took place on the Research Vessel Oceanus in a part of the Gulf of Mexico and relied on measurements taken by a special sensor called a chi-pod. It measures temperature gradients at high resolution using fast-response thermistors mounted on a cage holding conductivity, temperature and depth sensors. Those data, brought together, can be used to estimate turbulence.

The chi-pod was lowered into the ocean to profile turbulence all the way from the surface to 5 meters above the bottom. The device sampled distances of 4,000 meters, or about 2.5 miles, along the way.

Two weeks into the cruise, the team noticed a patch of strong turbulence occurring along a 700-meter (2,300-foot) vertical stretch of water near the ocean bottom. But there was no rough topography in the area, so what was going on? This was the head-scratcher that Holmes and others set out to answer.

"You could imagine in some ways how it could happen, but there's no evidence of it ever occurring before," said Jim Moum,

professor of physical oceanography at Oregon State University. "The nearest observation of strong ocean turbulence associated with rough topography was 1,000 meters away. So it was surprising."

Moum was responsible for organizing the five-week research cruise to study ocean mixing and invited Holmes, who had been studying equatorial mixing in ocean models for his doctoral dissertation.

Understanding the geographical distribution of turbulence in the ocean is something that has been key for some time, Moum says, because it's critical in determining how the ocean mixes. And so he and others looked at the measurements and began describing what they saw. But it wasn't enough.

"We needed a dynamical explanation, and it took some clever thinking and numerical modeling," said Moum.

That's where Holmes and Leif Thomas, Holmes' advisor and associate professor in Stanford's Department of Earth System Science, began working to solve the puzzle.

Using computer models, the two simulated how winds blowing across the ocean surface can generate internal waves that propagate vertically down through the ocean depths and transport the energy required to mix waters at the seafloor. But still, their model was not able to reproduce the observed mixing.

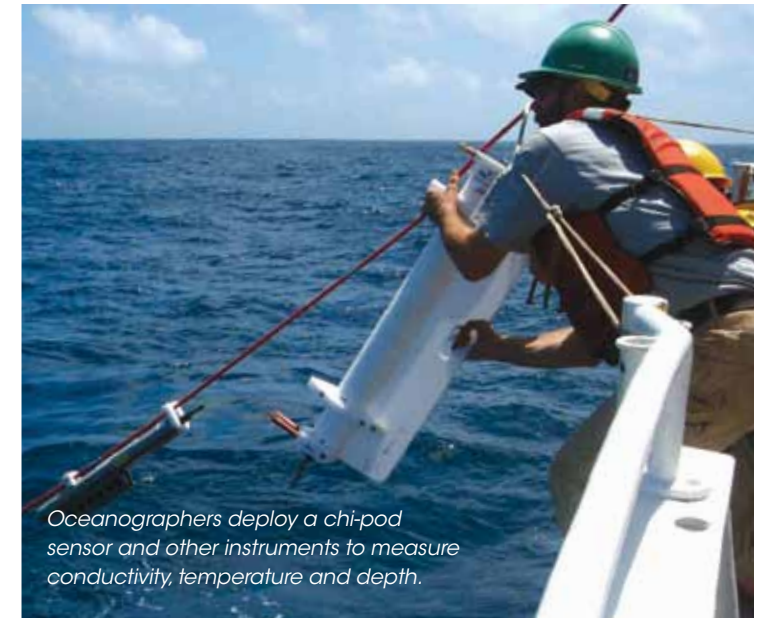
So Thomas got the idea to integrate something not usually considered in ocean models: the rotation of the Earth. And once Holmes plugged it in, the models began to make sense, revealing that the equatorial waters they studied were experiencing a small amount of vertical motion that could disrupt the internal waves enough to generate the turbulence.

The results are helpful in improving understanding of the dynamics responsible for generating turbulence in the ocean, Moum says. And there are plans to post the data from the effort, as well as those from about eight years' worth of profiling, in a publicly accessible database in the future.

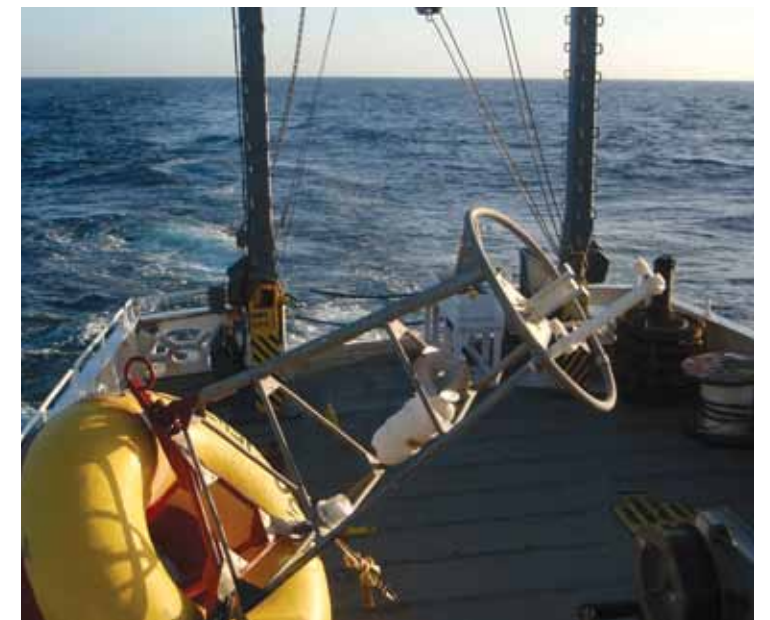
"What we're trying to do is extend these measurements for many El Niño - La Niña cycles that will tell us the roles of small-scale turbulence in El Niño and La Niña," said Moum. "They're both long processes, about five to eight years, and we want to get as many cycles as we can. But partly we're data poor because we only started systematic measurements fairly recently."

Some of the instrument arrays throughout the world's oceans that are helping to fill that data gap include the TAO array in the Pacific Ocean; the TIRATA array in the Atlantic; and the Argo network of floating profilers. The measurements collected by instruments in those arrays and human observers will ultimately get used in models to make future climate predictions more accurate.

Support for the research was provided by the Gulf of Mexico Research Initiative. 



Oceanographers deploy a chi-pod sensor and other instruments to measure conductivity, temperature and depth.



All Photos: Jim Moum / Oregon State University



Photo: Robert Heisenweber / NOAA

# ARCTIC COAST OCEAN MONITORING HEATS UP

NOAA scientists test a new buoy platform in preparation for increased monitoring in the United States' Arctic Exclusive Economic Zone.

BY DANIEL KELLY

Recent studies of changes to global climate have identified higher than expected acceleration in the warming of waters off the Arctic coast. The higher temperatures are linked to sea ice loss which is leading the growing anticipation of new Arctic shipping routes.

The projected expansion in maritime activities within Arctic waters has commercial, non-governmental and government agencies, including the National Oceanic & Atmospheric Administration's (NOAA) National Ocean Service (NOS), actively planning and preparing. An example of this is the NOS's Center for Operational Oceanographic Products & Services (CO-OPS) currently testing and developing systems for real-time monitoring of oceanographic and meteorological parameters in infrastructure-limited areas which can be applied in northern Arctic regions.

CO-OPS' scientists and engineers are working on options for coastal ocean monitoring stations that can provide measurements critical for maintaining the National Water Level Observation Network (NWLON), which contains more than 200 long-term observatories throughout the United States' coastal waters.

Recent station designs for remote coastal locations have a seabed platform (e.g., bottom mounts from Mooring Systems Inc.) with multiple sensors that measure pressure (for water level determination), salinity and temperature. Long-term system deployments in North Alaska will present installation challenges corresponding to each specific site of interest. For example, these stations need to keep operating for several years, even in harsh conditions, and one option to achieve this is to run a cable from an offshore station to a station onshore.

Short-term installations use similar bottom-mounted sensors as above, but are for temporary requirements, like filling gaps in monitoring during ice-free conditions, or supporting NOAA hydrographic survey applications or modeling applications. These bottom mounts are linked to surface buoys with acoustic modems which allow for the data to be relayed from the bottom mount to the buoy which then uses satellite telemetry for relaying data back to facilities on shore for researchers to have access to near real-time data.

Since the Alaskan offshore is a new locale for the observation network, researchers at NOAA are refining monitoring system design through Atlantic Coast field testing before any systems are placed along the remote coasts of North Alaska.

Steady operation of long-term pressure gauge systems in deep, offshore ocean sites has already been studied by the agency, while recent efforts by CO-OPS have focused on nearshore, real-time applications. One deployment of the buoy and bottom-mount system has been completed in the Chesapeake Bay, followed by another, more recent test deployment (September through November 2015) using the same buoy in St. Andrews Sound, Georgia along the Intracoastal Waterway.

"The main objective is to develop real-time systems that can be used in remote regions with very limited coastal infrastructure," said Robert

Heitsenrether, a physical scientist at NOAA. "Recently one area of primary interest is the Arctic Coast of Alaska," but having such systems would also be useful in keeping the agency's hydrographic charts up to date or providing ships and freighters with information on the water.

At the outset, NOAA scientists had a good idea for the type of short-term system they were looking to develop. Heitsenrether says the team was looking to build a platform for their needs, which included a buoy with a large instrument well, solar power and a weight of less than 300 pounds, so that it could be deployed easily from a small vessel. Aside from the buoy and power system, they also wanted to do all the system integration themselves, which would let them design and select the best mix of gear for NOAA's needs.

A NexSens CB-950 Data Buoy was purchased to serve as the platform's base. The researchers added a Sutron Xpert data logger to its well, which coordinates with a bottom-mounted Seabird SBE 26+ pressure sensor and a seabird Conductivity, Temperature and Density sensor (CTD) and topside Airmar weather station. Also mounted on top of the buoy are a GPS unit, to let managers know the platform's location at all times, and Iridium satellite communications gear.

Its first deployment, in Chesapeake Bay, took place in the fall of 2014 and was impacted by some setbacks. This included a nor'easter storm event that knocked out the data logger just five days after the buoy had been deployed. Going through the troubleshooting and repair process caused some headaches, but eventually, the buoy was repaired and redeployed for a short success at the tail end of the test. The researchers learned a lot along the way, Heitsenrether says, and as a result the 2015 version of the system was significantly improved.



Research scientists with the National Oceanic and Atmospheric Administration deploy a buoy in Chesapeake Bay.

So for the second go-around in St. Andrews Sound, Georgia, the enhanced system was deployed for a 60-day test from September through November 2015.


A cellular modem has been added to the platform, which can be turned on or off through commands sent to the Iridium modem onboard. That addition lets researchers communicate with the buoy remotely from any location. For the more-extreme situations, there is also a WiFi module that makes it possible to interface with the data logger from a boat within 100 feet of the buoy.

"We can hang a modem over the side of the boat," said Heitsenrether. "It's doable. It's just not convenient."

Those improvements proved to be very helpful as the scientists embarked on conditions in the St. Andrews Sound, which present more currents than the buoy has dealt with so far. In the Chesapeake Bay, there was more wave energy, but less currents and a significantly smaller tidal range, Heitsenrether says.

This most recent field test successfully concluded in late November. The bottom-mount and buoy system completed 60 days of real-time operation, with greater than 95 percent data throughput.

Heitsenrether adds that improvements following the St. Andrews Sound operation could include enhancing technology used in the underwater acoustic modems, both in deep and shallow waters. And there is a need to find a reliable two-way communication option that works globally since there are limited two-way communication options at high latitudes.

"The big picture idea — pending funding and planning — is to test deploy this system at a site in Alaska within the next year or two. The plan is to take it up to the North Coast of Alaska somewhere," said Heitsenrether. "As far as the two tests we've conducted, our team considers the system design to be mature enough for operational applications. There are a few minor system refinements to implement this year but the system should be ready for a test in Alaska this coming summer." 

## COASTAL BUOY SYSTEM

A NexSens Technology CB-950 data buoy provides a floating platform for the NOAA Arctic monitoring system. An Airmar 200WX Ultrasonic WeatherStation Instrument is mounted on the buoy's top plate along with a GPS Receiver. Below the platform is a bottom-mounted Seabird SBE 26+ pressure sensor and a Seabird conductivity, temperature and density sensor. Data from the instruments are logged internally by a Sutron Xpert data logger and transmitted to researchers via Iridium satellite telemetry.

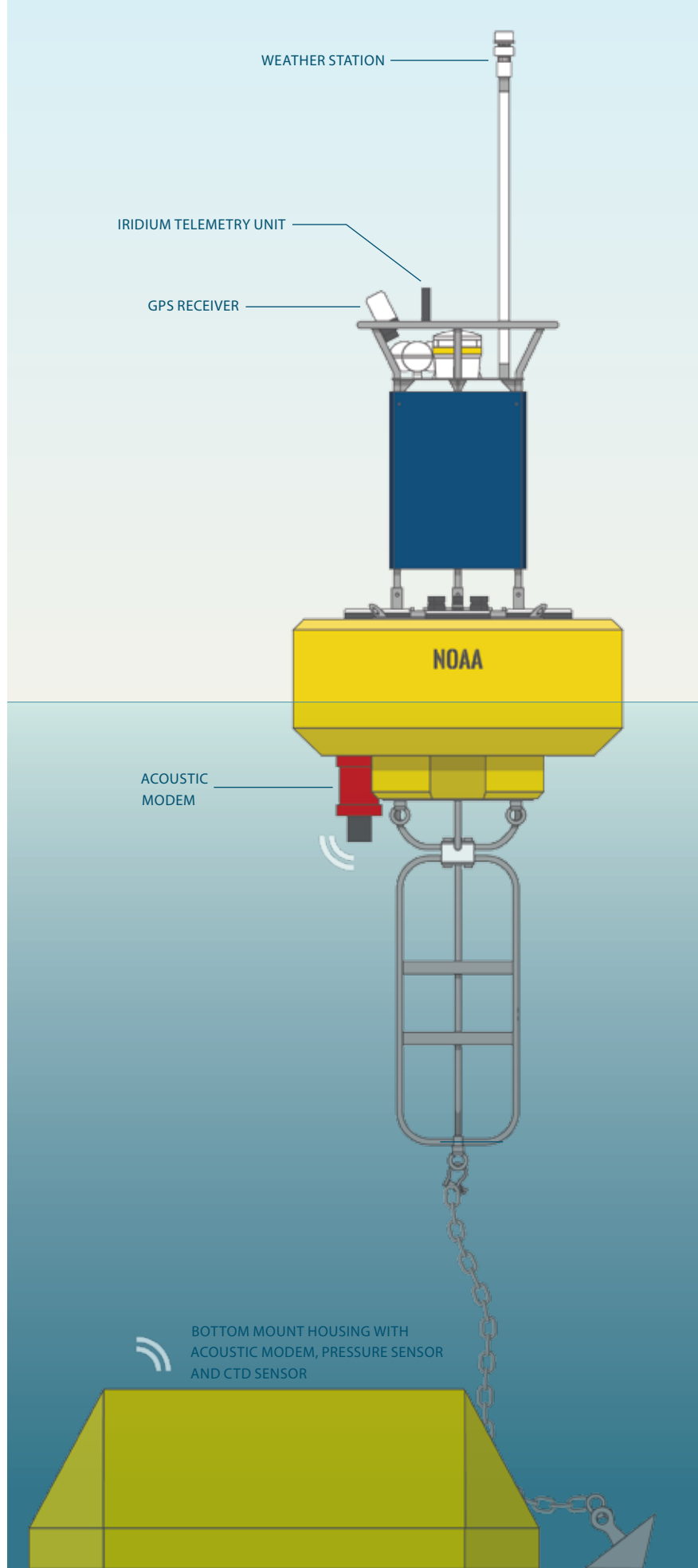


Photo: (Left) Robert Heitsenrether / NOAA; (right) Nate Christopher / Fondriest Environmental

# ADVANCING REMOTE DATA

The U.S. Geological Survey and NASA's Jet Propulsion Lab join up to ground-truth the PRISM sensor, which may soon streamline remote water quality monitoring.

BY DANIEL KELLY



Monitoring water quality in inland bays and estuaries is tricky even over the short term. Conditions can shift quickly, not in days or weeks – but within minutes.

Because of that variability, a number of research efforts have tried their hand at eliminating it using remote sensors. Most of these rely on light penetration and reflectance to see what we can't see with the naked eye.

One of the most recent efforts to minimize this uncertainty through remote sensing relied on a collaboration between the U.S. Geological Survey and NASA's Jet Propulsion Laboratory. Scientists from both organizations paired off into two teams to study the dynamics of water quality in San Francisco Bay. One group completed manual sampling of the bay while the other conducted flights over the area in an aircraft equipped with the new PRISM sensor (portable remote imaging spectrometer).

The ultimate goal of the work was to vet the reliability of the PRISM sensor for deployment on satellites in the future.

"The question we were seeking to answer was: Can we do this at all?" said Brian Bergamaschi, biogeochemist with the U.S. Geological Survey. He is also a co-author on an article detailing the study's results published in the journal *Environmental Science and Technology*. "...The tides, if you take a picture right now and then take a picture 20 minutes from now. They will look very, very different."

His end of the work dealt with taking measurements on the ground from San Francisco Bay. This involved speeding around the bay with a sampling system designed for taking water quality measurements at high speed. The approach is similar to that of the FLAMe sampler, a high-speed rig also developed by the U.S. Geological Survey but is more commonly deployed on lakes and targets different parameters.

"The FLAMe sampler has a different suite of measurements," said Bergamaschi. "We're using the same sort of idea. But they have a cooler name."



U.S. Geological Survey scientists prepare to take spot field measurements in the San Francisco estuary.



For this effort, Bergamaschi says that he and others working in the bay were primarily concerned with total suspended sediments, turbidity, methylmercury, dissolved organic carbon and levels of chlorophyll.

"In estuaries, things change quickly over space and time. You have to take measurements quickly," said Bergamaschi. "Our boat was equipped to do that with various optical instruments to calibrate what the satellite should see, the actual, specific properties of the stuff in the water. Fifteen different instruments."

This high-speed approach was complemented by manual sampling in the bay, as well as lab analysis of water samples. From there, ground data were compared to those gathered by the aircraft-mounted PRISM sensor.

The results were excellent, Bergamaschi says. For all of the parameters that they were interested in, the sensor was able to tease apart different colors in the images it collected and identify what they were.



"We're surprised it worked as well as it did. It's a pretty expensive thing to do, but we wouldn't have done it if we weren't confident that it would work," said Bergamaschi. "It's a pretty forward-looking project."

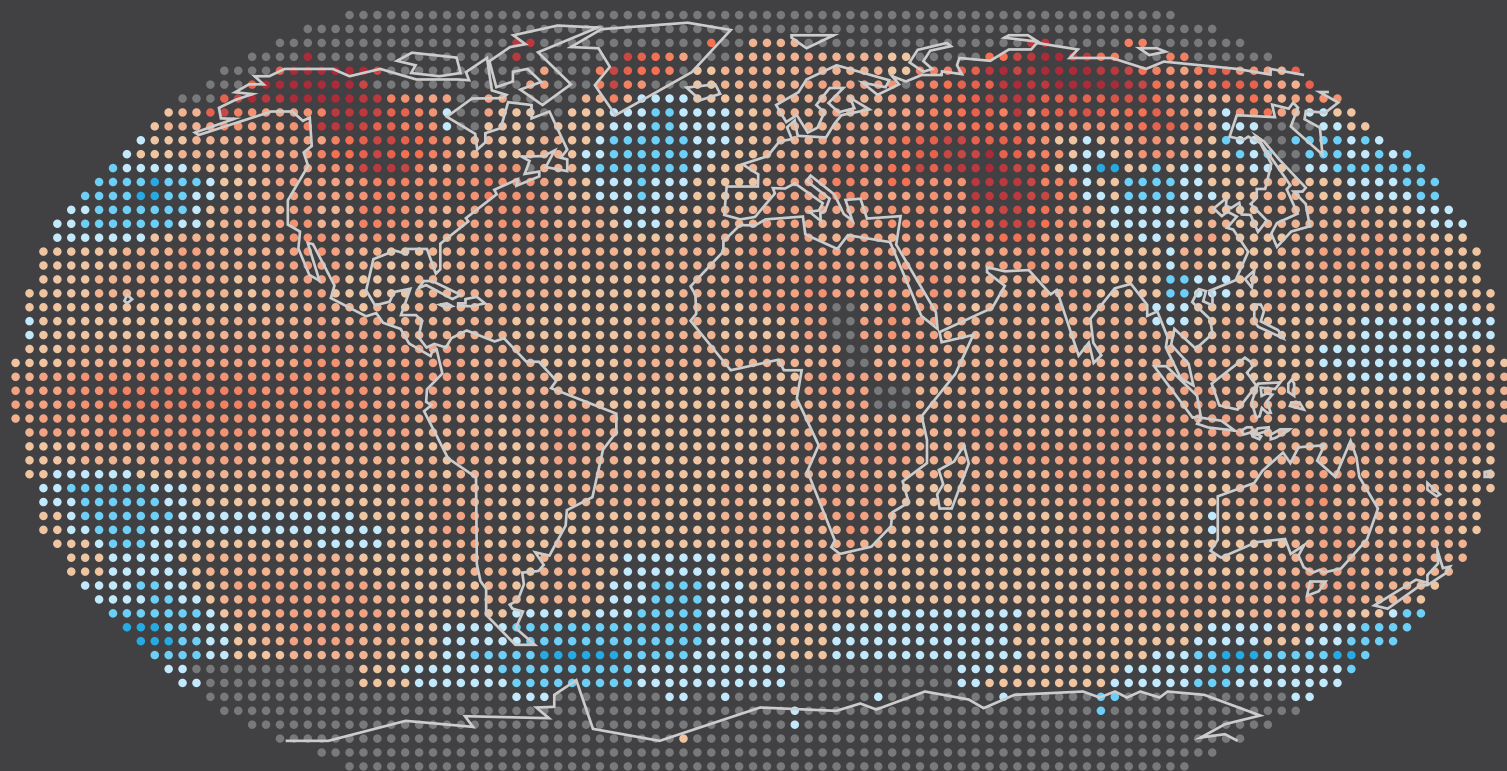
In the bay, he says, the results will prove useful for improving the understanding of its dynamics. A number of efforts keep track of conditions in deep parts of San Francisco Bay, but the shallows are not as well studied. "It opens up a geography that we didn't have access to before," said Bergamaschi.

The findings may also help monitor the water quality in other inland bays and coastal areas of the United States. Any near-shore environment with high turbidity levels could benefit, Bergamaschi says. In the future, he is looking to apply some of the same techniques to lakes in Alaska. 

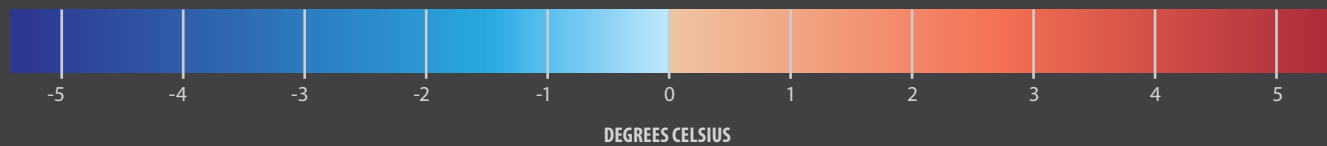
All Photos: U.S. Geological Survey

# TEMPERATURES ON THE RISE

Temperatures across the globe continue to rise year after year and the first half of this year hints that 2016 may surpass 2015 as the hottest on record.

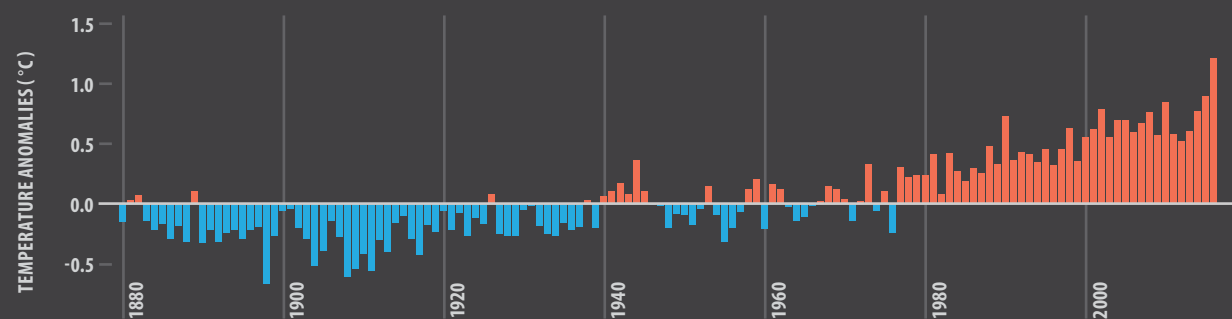


LAND & OCEAN TEMPERATURE DEPARTURE FROM AVERAGE JANUARY - MARCH 2016  
(WITH RESPECT TO A 1981-2010 BASE PERIOD)

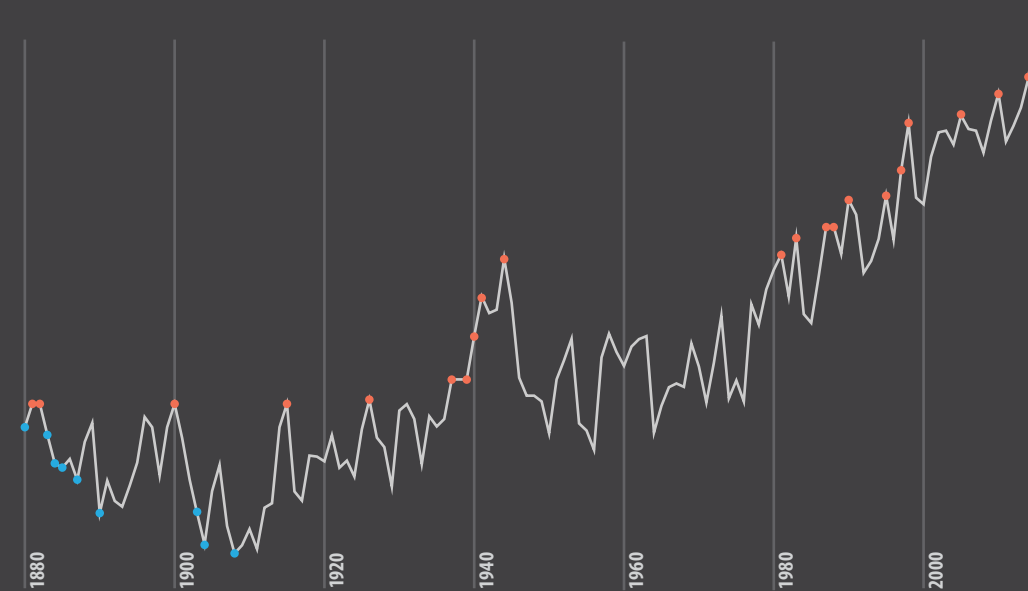


## A LOOK AT THE PAST

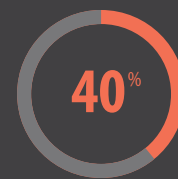
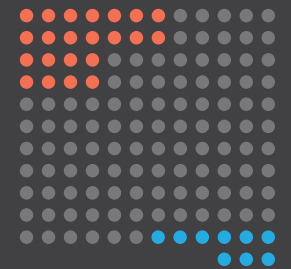
Land and ocean mean temperature anomalies from March 1880-2015 show a long rising trend.



## BREAKING RECORDS



In the past 135 YEARS there have been...  
**22 RECORD HOT TEMPERATURES**  
and only  
**9 RECORD COLD TEMPERATURES**



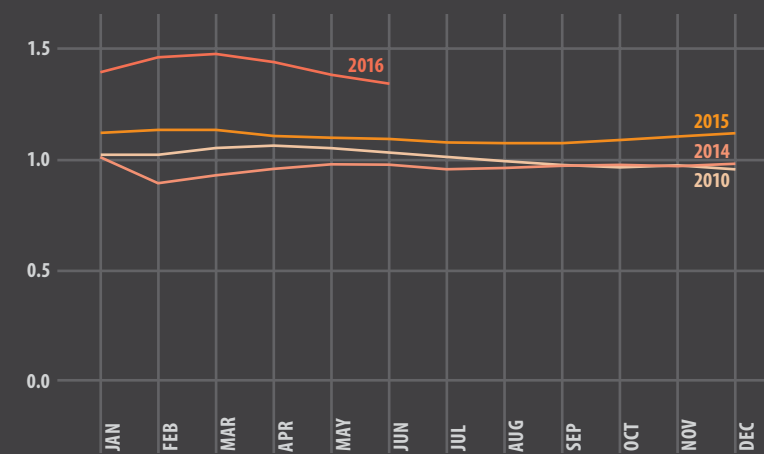
There have been **4 HOT TEMP RECORDS** in the last **DECADE** alone.

There have been **107 YEARS** since the last **RECORD COLD YEAR** and it looks like that gap will only increase in the near future.



## 2016 SO FAR...

The 2015 El Niño has given 2016 a strong head start to becoming the hottest year on record. As of June, Earth is experiencing its 14th consecutive record-hot month. The second half of the year is still to be determined, but 2016 is well on its way to breaking more records.



**↑ 1.05°C**  
YEAR-TO-DATE TEMPERATURE INCREASE OVER THE 20th CENTURY AVERAGE

All Graphics: Nate Christopher

Information from:

National Oceanic and Atmospheric Administration — [ncdc.noaa.gov](http://ncdc.noaa.gov)  
NASA Goddard Institute for Space Studies — [giss.nasa.gov](http://giss.nasa.gov)  
Climate Central — [climatecentral.org](http://climatecentral.org)

See more of our infographics at [fondriest.com/news/tag/infographic](http://fondriest.com/news/tag/infographic)

# PHOSPHORUS IN LAKE ERIE SEDIMENTS

An effort led by a consortium of Lake Erie researchers answers long-standing questions to the issue of phosphorus in Lake Erie sediments and its effect on algal blooms.

BY DANIEL KELLY

What happens to algae-feeding phosphorus in Lake Erie that isn't used up by microbes but instead stays in the sediments? Does it have impacts on the algal blooms that hit the lake the following year? These questions have intrigued Great Lakes researchers for some time and have recently been answered thanks to an investigation by a consortium of Lake Erie researchers.

Findings of the work were shared during an Ohio Sea Grant webinar on July 7. Numerous updates were given to the media by Lake Erie scientists, covering tributary nutrient monitoring, the Lake Erie algal bloom forecast for 2016 and predicted climate change impacts on the lake's recurring blooms. A recording of the briefing is posted on the Sea Grant's YouTube account.

Tom Bridgeman, associate professor at U. of Toledo's Lake Erie Center, discussed the study in which he and numerous collaborators dissected the issue of sedimentary phosphorus over a two-year period. A large goal at the outset of the effort was to pinpoint just how much that phosphorus retained by sediments was contributing to blooms in the following year. A high figure would mean management strategies needed an update.

The U.S. and Canada have agreed to reduce the amount of phosphorus going into the lake by 40 percent in a bid to minimize algal blooms and their detrimental effects.

"This leads to some serious questions. One is the question of, 'What about all the phosphorus that's already in Lake Erie?'" said Bridgeman. "We've got all the external loading coming from the Maumee and other tributaries. But what about internal loading,

or internal recycling, of phosphorus from the sediments, so all this phosphorus already in Lake Erie sitting in the sediments? What is that going to do?"

The next question scientists sought to answer from that point was, even if that 40 percent reduction can be achieved, will algal blooms go down as hoped? And, much farther down the road, researchers looked to gauge whether climate change would increase or decrease phosphorus loading.

In 2012, Bridgeman noted, there was a very dry year that resulted in a small algal bloom in Lake Erie. This followed the massive 2011 bloom, helping to inform a guess that the sedimentary contribution to blooms was pretty low. If there had been a lot of carry over, then that 2012 bloom would have been much larger.

"Maybe that small bloom that we got in 2012 was due to a little bit of hangover. Or it was due to waste from the plants or dredging or other things, but that clue shows us how internal cycling of sediments probably is not going to be such a big problem," said Bridgeman. "But we don't know that. That's just kind of looking at that and it's probably what we'd think, but we really need to measure that."

To tackle the issues, he and others involved needed updated sediment data from western Lake Erie because those available at the outset were about 30 years old. Sites throughout the area were sampled to gather sediment cores, including some that were also surveyed with the help of plexiglass bottom chambers. These were placed by scuba divers who dived to them to gather water samples over the course of several days.

One issue that researchers encountered in the effort was the fact that there are many different methods for assessing phosphorus flux from sediments. To get around that, they approached testing it with as many as they could. Scientists used aerobic and anaerobic incubations, phosphorus electrodes and pore water expression, among others.

"We wanted to do it a lot of different ways to see if we could get a consensus of methods, whether they agree ... We tried all of these different methods," said Bridgeman. "The bottom line is that they all agree. Whatever method that we used to measure phosphorus, how phosphorus was coming up off the bottom, pretty much gave us the same answer."

Which was that around 1.4 milligrams of phosphorus per square meter each day comes off the sediments in the western basin. Over the course of a summer, that equals about 3 to 7 percent of the targeted nutrient load coming in from tributaries.

"So really, that's not very much. Under normal conditions when the lake is oxygenated, the sediments are oxygenated, we don't think that there's much phosphorus diffusing up from the bottom," said Bridgeman. "The impact of external phosphorus load reductions will not be substantially delayed by internal recycling. That was our main conclusion there."

As for what may happen in a future of predicted climate change, researchers used Soil and Water Assessment Tool (SWAT) models to forecast impacts. They considered four different scenarios ranging from mild to severe changes.



A rosette of niskin bottles and other scientific instruments to sample Lake Erie's water in a profile.

Under a mild scenario, researchers modeled that winter loading would go down, while spring loading stayed fairly typical and summer and fall loadings went down. In all scenarios, loads for summer and fall dropped.

"But if we get the most severe climate change scenario, we're going to get a lot more winter loading and more spring loading," said Bridgeman. "So the effect of climate change is going to depend on how severe it is. If we get moderate warming, it could actually be good for us. It could decrease Maumee River loads. But if we get extreme warming scenarios, then it's going to increase Maumee phosphorus loads."

Western basin loading simulations also proved that the 40-percent reduction target was a good one. These showed that reducing loads from its tributaries would decrease algal bloom biomass considerably from a baseline representing the 2014 bloom.


Additional contributors to the work represented Case Western Reserve University, LimnoTech, the National Center for Water Quality Research, Ohio Lake Erie Commission and Ohio Sea Grant. Funding was provided by the U.S. Environmental Protection Agency's Great Lakes Restoration Initiative. 

Photo: NASA Earth Observatory

Photo: University of Toledo

# GEORGIA COASTAL NUTRIENTS

A study in Georgia's Ogeechee River estuary sampled with the incoming tide to provide data on nutrient conditions for state modelers.

BY DANIEL KELLY

Nutrient pollution is clearly a problem in United States waters. But what will the issue look like in the future? It's a tough question to answer, but researchers in many states are approaching it in recent years thanks to a 2013 request from the U.S. Environmental Protection Agency that they adopt nutrient water quality standards.

One of the states at the fore of adopting the standards is Georgia, whose Environmental Protection Division (EPD) has supported work by researchers at the University of Georgia's Skidaway Institute of Oceanography to study nutrients pulsing through the Ogeechee River estuary. The goal is to gather a lot of quality data for use in modeling that can predict how conditions may change there in the future. Data may be useful elsewhere in the region, as it is similar to other estuaries lined with salt marshes along the state's coast.

For those at the university, the river was an ideal spot for sampling because of its location nearby. Past researchers at Skidaway have also already sampled the river, providing some useful background on its conditions.

Studying the Ogeechee River's nutrients relied heavily on the use of a research vessel that investigators drove down the waterway at a pace of about 8 knots as the tide was coming in. Onboard, a suite of sensors gathered critical data on parameters including chlorophyll, dissolved oxygen, colored dissolved organic matter, fluorescence, conductivity, temperature and depth.

"Eight knots is about 10 mph," said William Savidge, assistant professor of oceanography at Skidaway. "So we were moving at a brisk trot."

That pace to keep up with the tide helped researchers to account for the channel itself. If waters were too high, they would essentially not be sure that they were sampling where they needed to. But going with the tide also took the surrounding salt marshes into consideration.

Savidge says that he and others involved, including Kate Doyle, a researcher at Skidaway, wanted to ensure that whatever the marshes added was assessed at low tide.

"When the marshes flood, there is a net change in the amount of chlorophyll — marshes contain a good bit — and they contribute organic matter," said Savidge. "We wanted to make sure we captured the contributions of marshes at low tide after the fact, after they'd drained ... If we had sampled on a high tide, we might have missed the contributions of processes happening on the flooded marsh surface (such as removal of chlorophyll or addition of phosphate). Everything is confined and concentrated in the channel at low tide."

Measuring those and the larger dynamics at play in the surface waters of the Ogeechee River estuary took a great number of instruments rigged up to sample in a flow-through system. Water was drawn through tubing mounted through a bilge pump on the side of the ship and passed through a WET Labs FLNTU (combines fluorescence and turbidity), a fluorometer and a YSI 600 OMS Optical Monitoring Sonde. A nearby tube held an S::CAN absorbance spectrometer for tracking photodegradation of organic matter as it moves downstream. A Seabird CTD (conductivity, temperature, depth) sensor was also used.

In the Ogeechee River, the total number of sampling runs was 10, including two per quarter for a year and an additional two opportunistic runs that were completed to take advantage of boat time while the craft was in use for another study. A few profiling runs using the same instruments were also completed in the Altamaha River, Savidge says, to support additional studies going on at the University of Georgia, Athens.

Researchers found that the upper estuary is mostly freshwater, while the lower half is more salty. Near a loop in the middle, there's a transition.

"We're seeing all the usual estuarine gradients (in one transect from August)," said Savidge. "We are seeing some evidence of hotspots. There are high concentrations of chlorophyll occurring between a sharp transition to freshwater at the end of the river. High chlorophyll is associated with changes in CDOM. Downstream, there are significant changes in salinity. There are almost two estuarine systems."

Data on organic matter and absorption haven't been fully processed yet. But Savidge expects they may reveal a degradation

*Instruments, including a YSI 600OMS Optical Monitoring Sonde, ready to profile the Ogeechee River. The rack was scavenged from another project and modified to hold the instruments in place.*

of organic matter as it moves downstream. Woodlands and marshes along the river help to contribute a lot of that matter, he says.

As for some unexpected results, Savidge notes that there's a very strong drawdown of chlorophyll in the middle of the estuary in the summer. There's also a coinciding peak in concentrations of nitrites and phosphates. He's likewise registered a big change on the 15N (isotope of nitrogen) side of some particulate organic nitrogen fractions.

"Suggests to me that there is a very active nutrient recycling zone in the middle estuary in the summer. But by late fall (December) through our last spring sampling in late April, the river properties look mostly conservative with most gradients indicative of simple dilution of a riverine source through the estuary," said Savidge. "I was surprised at how fast the summer - fall transition was. And I was surprised by how strong the summer chlorophyll drawdown was."

Those results and others will be highly useful for water managers at the state Environmental Protection Division. They are largely focused on nutrient loads and their effects across much of Georgia's coast.


"We've got five rivers going into the coast. Each has a main estuary and the whole system is connected by marshes and channels," said Savidge. "We're not going to get answers by just looking at data. The EPD is putting together an estuarine model and we're ultimately providing food for their modeling efforts. It would take a decade of data collection to do otherwise." 

Photo: Mike Robinson / University of Georgia





MONITORING  
GEAR

### Van Essen CTD-Diver

To monitor groundwater levels and saltwater intrusion, injected wastewater, or contamination from chemical discharges and landfill sites, the CTD-Diver is a good choice. It features a rugged, corrosion-proof ceramic housing and is equipped with a four-electrode conductivity sensor to measure electrical conductivity from 0 to 120 mS/cm. There are two options for measuring conductivity: true or specific conductivity at 25 degrees Celsius. It also tracks pressure and temperature.



### INW TempHion

The TempHion is a submersible water quality sensor and data logger that includes a pH/ORP element as well as one thermistor-based temperature element. With a patented reference electrode, the TempHion provides long-term stability for continuous or intermittent monitoring. This makes unattended, in-situ pH testing possible without frequent calibrations or service.

### Lufft WS800

Track all the essential weather parameters with the Lufft WS800. These include air temperature, humidity, pressure, wind speed and direction, plus solar radiation and lightning. The sensor easily mounts to a 2-inch diameter pipe with an integrated bracket mount & U-bolts. Data output via Modbus and SDI-12 for streamlined integration with NexSens and other leading data loggers.



### YSI EXO Handheld

An updated EXO Handheld Display boasts improved ease-of-use and performance for YSI's line of EXO Multi-Parameter Water Quality Sondes. It features a waterproof, IP67-rated body resistant to impacts as well as a wet-mate connector. Inside, a GPS locator helps customers keep track of all their sites and a rechargeable lithium-ion battery ensures reliable logging. A refined user interface chips in help menus and walkthroughs to get users up and running quickly.



### Heron dipper-Tag

The dipper-Tag is an economical, multi-purpose meter designed for use in monitoring or installing groundwater wells. To achieve its inexpensive cost, it is available in only one length: 500 feet. The dipper-Tag comes with a spring-release clip that allows users to swap in bailers or ploppers to measure water levels acoustically. A 316 SS weight comes included to measure to the bottom of wells. Attach a dipperLog to the meter and it can also be used in short-term temperature and level tracking.



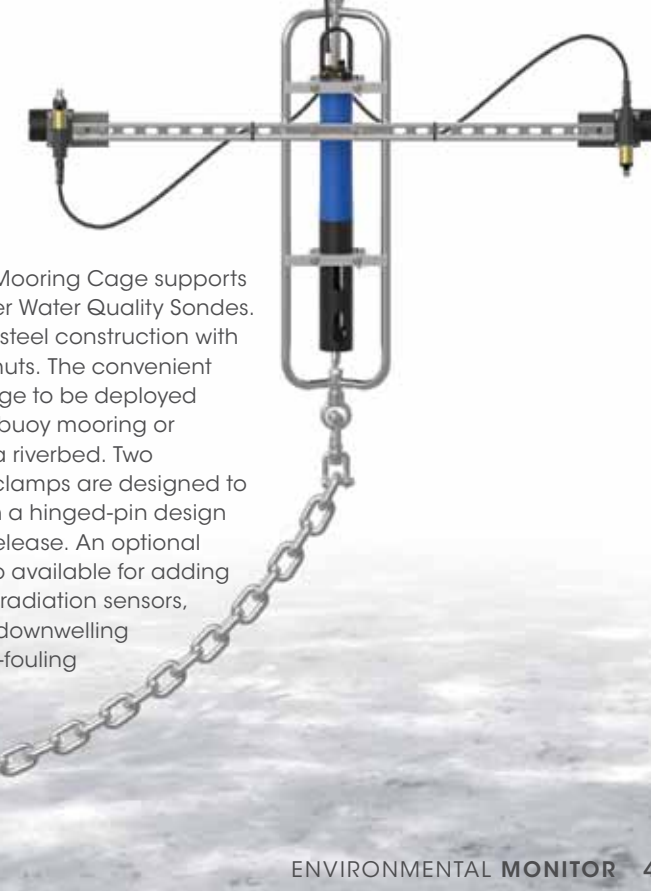
### Solinst AquaVent

Obtain accurate water level and temperature measurements in shallow groundwater and surface water applications with the Solinst AquaVent Vented Water Level Datalogger. The AquaVent uses a gauged pressure transducer that is open to the atmosphere via a vented cable. The vented transducer is made of Hastelloy and is extremely durable and accurate in a wide range of temperatures. The AquaVent can hold up to 120,000 data sets when programmed in Solinst Levelogger Software with a compressed linear sampling mode.



### NexSens EXO Sonde Cages

The NexSens EXO Sonde Mooring Cage supports all YSI EXO Multi-Parameter Water Quality Sondes. It features a 304 stainless steel construction with top and bottom 3/4" eye-nuts. The convenient connection allows the cage to be deployed in-line on an open-water buoy mooring or mounted horizontally on a riverbed. Two integrated PVC mooring clamps are designed to hold sondes securely with a hinged-pin design for quick clamping and release. An optional mounting crossarm is also available for adding photosynthetically active radiation sensors, as well as upwelling and downwelling sensors with optional anti-fouling wipers.



### Juniper Systems Mesa 2

Running Windows 10, the rugged Mesa 2 brings powerful functionality to mobile data collection, featuring a large, 7-inch, extra-bright display for easily viewing maps or images and battery power that lasts up to 15 hours. With a full Windows operating system, users can carry out the entire data collection process from start to finish. Snap a photo, record field notes, or capture a GNSS location and then analyze the data right there with the Mesa 2.





# GREEN INFRASTRUCTURE TRADEOFFS

In the field with Northern Kentucky University scientists studying greenhouse gas flux in constructed wetlands and other green infrastructure sites.

BY DANIEL KELLY

Green infrastructure installations, like green roofs, permeable parking lots or bioswales, are increasingly popular these days. They are built for good reasons, like decreasing urban runoff or improving a stream's water quality, among other things. But as with anything, there are tradeoffs to implementing them.

A study led by scientists at Northern Kentucky University is evaluating some of the costs and benefits to using one type of green infrastructure in a study considering constructed wetland sites in Kenton County, Kentucky. The research, led by Sarah Stryffeler, an undergraduate student studying environmental science, has looked at multiple sites using gas-catching chambers that have given scientists the means to analyze the greenhouse gases emitted by the manmade wetlands.

The Environmental Monitor caught up with the NKU team while they visited one of the wetland sites, in the middle of Cappel Park near Covington, Kentucky. The constructed wetland there is used as a filter to help clean water that flows into a tributary of the Licking River, which later empties into the Ohio River.

"That's what this site is, and so, in an urban area, people are putting in wetlands and rain gardens and retention ponds and

all these different things to deal with stormwater runoff. And we know that they're really beneficial in improving water quality, but nobody's looking at what some of those tradeoffs might be," said Kristy Hopfensperger, associate professor and director of the environmental science program at NKU. "So if we put in a bunch of wetlands, yes, we know we can improve water quality, but are we throwing more methane into the air of an urban environment. So what might tradeoffs of the green infrastructure be?"

Methane is just one of the greenhouse gases that is being considered in the study. The other two are carbon dioxide and nitrous oxide. These are evaluated using chambers that segment small portions of wetland and capture the gases they emit. The circular gas-catching chambers don't have bottoms so their walls can be shoved into the dirt to create the study plots. Each features a special construction to ensure a gas-tight seal.

The researchers take the chambers to every site, deploy them, and then collect samples of the gases emitted via syringes that insert into the lids. Samples are gathered every 10 minutes for a half hour during each deployment. From that point, they are analyzed using a gas chromatograph.

"So we trap atmosphere and we see what happens to that atmosphere with its change in greenhouse gas composition for half an hour to get that rate," said Hopfensperger. "Because the rate is more interesting to us — how fast the greenhouse gases are moving in and out of the soil. That is more interesting than just the actual concentration itself."

Measurements of soil moisture, temperature and organic matter are also taken.

"Soil moisture is used as a proxy for letting us know if the system is aerobic or anaerobic. So if there's no oxygen in the soil, if it's an anaerobic situation, then you're going to have really high soil moisture," said Hopfensperger. "There's going to be a lot of water in the soil pore space instead of oxygen."

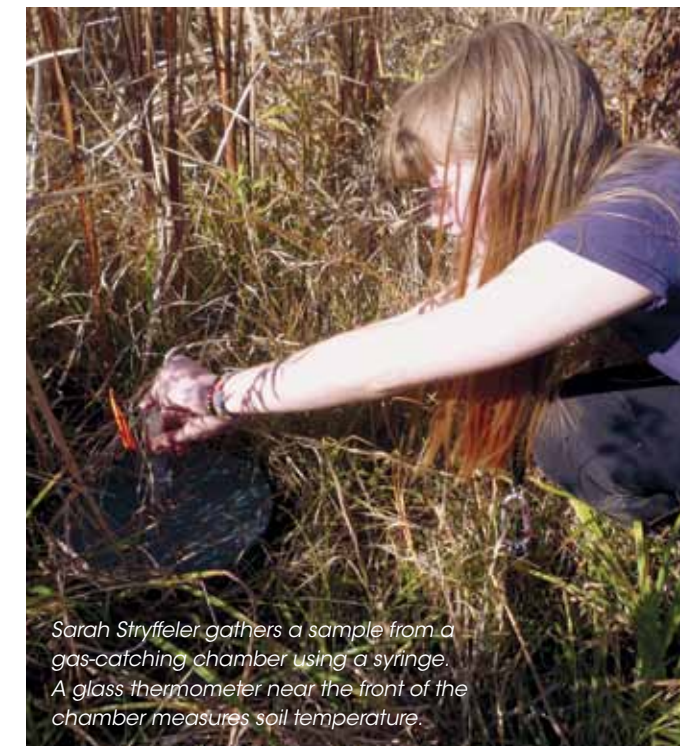
Temperature is useful for gauging microbial activity, she says, because greenhouse gas fluctuation can increase as conditions get warmer. Organic matter is a metric that helps answer decomposition questions.

Soil temperature is tracked with a regular glass thermometer that can be stuck in the muck. For moisture, researchers use a two-pronged soil sensor.

"We need it (the soil sensor) to be kind of level with the chambers so that we know that they have the same moisture content," said Stryffeler, as she stuck the soil probe into the dirt near a gas-catching chamber. "And then, this is super easy, all that you do is press 'on' and then it just tells you what your reading is."

Those measurements have helped the scientists make some interesting finds about the wetland we visited, as well as some of the others under study.

"This site is our most natural-looking, with thick vegetation. And we have the highest CO<sub>2</sub> rates here, which makes sense because you're going to get a lot of respiration from the plants,"



Photos: Daniel Kelly / Fondriest Environmental

Sarah Stryffeler gathers a sample from a gas-catching chamber using a syringe. A glass thermometer near the front of the chamber measures soil temperature.



Kristy Hopfensperger inspects a gas-catching chamber after sampling.


said Hopfensperger. Another site, a retention basin, was found to be sequestering methane. All of the sites, except for one that was barely sequestering nitrous oxide, were found to emit nitrous oxide. "Our ranges are within (those of) the natural (not manmade) systems, but they're lower. So far, we're finding that these ecosystems are not emitting as much greenhouse gases as some of the natural systems might be."

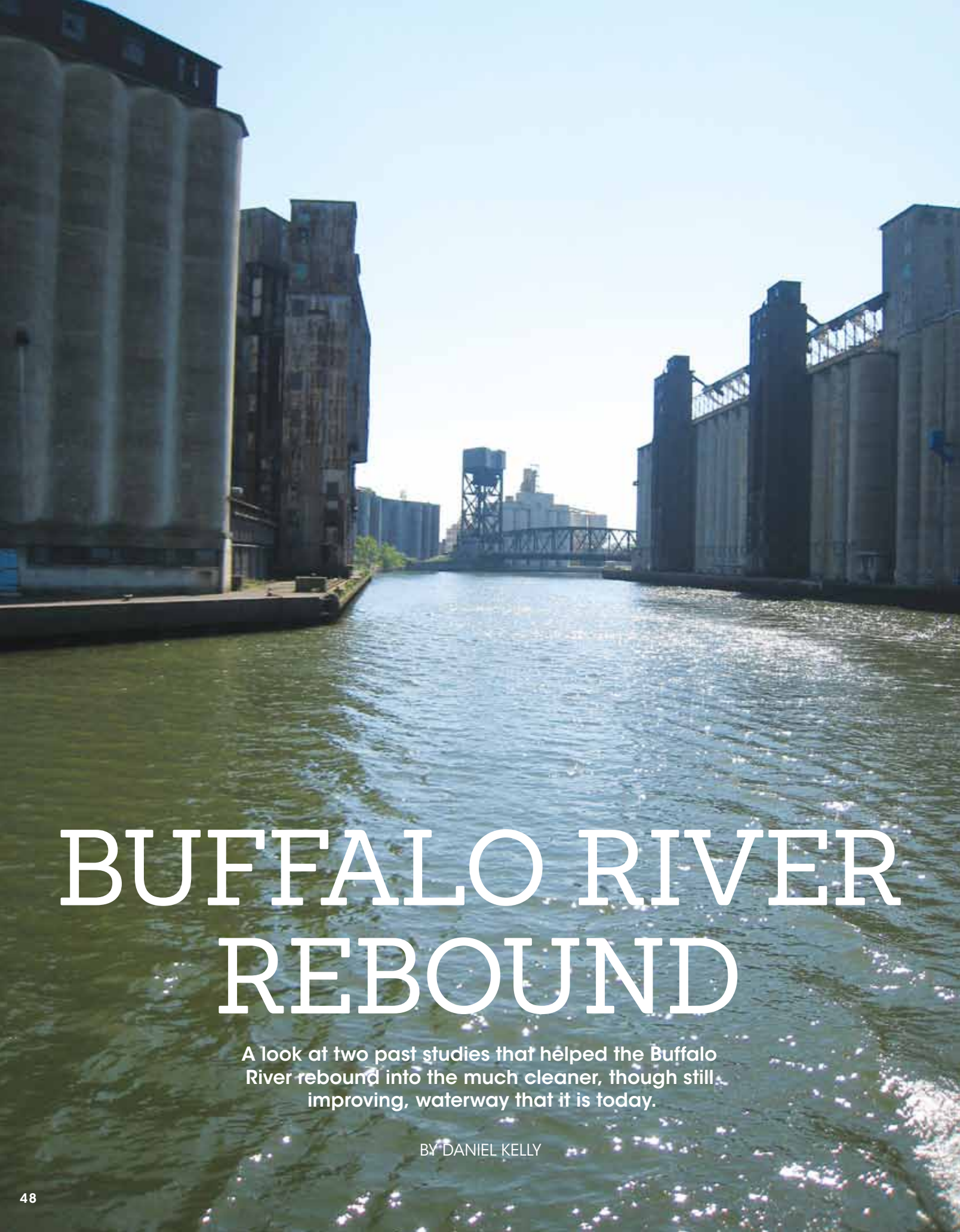
Hopfensperger says that the lower rates might be due to the fact that there's less organic matter in the constructed wetlands compared to natural sites that have been in existence much longer.

Still more data need to be collected, she says. And one thing that would really help the effort is to do a mass-balance of gases emitted across sites.

"So with an ecosystem, you can say, 'Hey, this ecosystem's emitting methane, but at the same time, all this vegetation's taking CO<sub>2</sub> out of the atmosphere.' So you have to kind of balance that," said Hopfensperger. "You can say emitting methane is bad. We know it's a harmful greenhouse gas, but maybe the wetland takes in so much more CO<sub>2</sub> that it offsets it and it's not really a big deal. So right now we're just gathering the data on the greenhouse gas rates. And that would be the next step to kind of calculate those mass balances."

Moving forward, Hopfensperger is hoping to use data collected during the project, which began in June 2015, in funding proposals that could lead to larger studies into the tradeoffs that green infrastructure projects present. For Stryffeler, the work so far has helped get her feet wet in studying environmental science.

"I'm hoping to go into environmental engineering eventually. That's the dream," said Stryffeler. "Renewable energy or oceans cleanup. So this is my experiment of 'is this really what I want to do for the rest of my life.'" 



# BUFFALO RIVER REBOUND

A look at two past studies that helped the Buffalo River rebound into the much cleaner, though still improving, waterway that it is today.

BY DANIEL KELLY

Back in the 1960s and 1970s, the Buffalo River was an industrial wasteland. Up and down its banks were plants owned by companies like Allied Chemical and Republic Steel. These pumped out pollutants without much hindrance, setting the river's course toward disaster.

The effects of all the industrial waste and the apathy that let it course through the currents of the meandering Buffalo River were substantial. Thermal pollution was rampant and waters in the river were near 100 degrees Fahrenheit year round. Add to this the oil slicks and all the cancer-causing gunk that was amassing in the river's sediments and it's easy to see why wildlife didn't want to make a home there.

But given the right actions and regulations, along with precise research into what the river needed, the Buffalo River has made a rebound. This is the story of its redemption, with a focus on the turning point that began the slow march to bringing the river back from its catastrophic environmental state.

It begins with the realization that the river really was in a poor condition, that something needed to be done about it and a look at some of the first steps taken to help turn around its health. It goes on to highlight a more recent investigation that reveals how the river is doing in the present day.

## TURNING POINT

Well before the famous Cuyahoga River Fire of 1969, the Buffalo River had burned something fierce. But there wasn't the same amount of media coverage for the event -- why?

"It was the original industrial river that caught on fire, but the Cuyahoga (River) gets more press. It was because the oil slicks caught on fire," said Bob Baier, executive director of the Industry/University Center for Biosurfaces at the University at Buffalo. "I had the interesting eye of being a young environmental scientist those days, sampling the oil slicks and (occasionally) pulling up dead bodies."

The river that exists today is far different than the one Baier encountered when he was just starting out as a researcher. And so is the technology that is used to monitor the river. Back in the late '60s and early '70s, many of the devices that environmental scientists depend on today simply didn't exist yet. This meant that Baier, who was working at the Cornell Aeronautical Lab at the time, had to invent tools to get the job done.

The big problem was all the oil. Slick after slick everywhere along the river, and it just kept coming. Baier told us stories of children who would go swimming in the water only to come back with rings of oil clinging to their skin. And another detailing how the currents carried oil downstream to a local yacht club where it adhered to all the rich people's boats.

That may or may not have been one of the reasons that then-Congressman Jack Kemp would begin working with federal agencies to get funding for cleaning up the waterway. But his efforts and those of others amidst the growth of the environmental movement would draw more attention to polluted waterways like the Buffalo River along the way toward important milestones like the Federal Water Pollution Control Act and the formation of the U.S. Environmental Protection Agency.

It was amidst this growing support for environmentalism that Baier and others set out to study the usefulness of oil skimmers that could help to clean up the river, or at very least keep the quantities of oil flowing in from becoming too burdensome.

Back then, there were no oil dispersants, like the kind used after the 2010 Deepwater Horizon disaster. And so the invention of compounds that could whip the stuff up into collectable globs would become a milestone discovery of the period, something Baier had a personal hand in. Getting there would take the tech of the day, with some finagling by determined scientists, and a little luck.

"What we were doing predominantly was sampling oil slicks. There were browns and greens floating downstream past Michigan Street," said Baier. "We'd collect the oil, analyze it and try to pinpoint its origins. The City of Buffalo had a huge problem with merged stormwater, so diesel fuel, gas station dumping -- after a big rain, that would come into the Buffalo River, which augmented what industry was putting in. The fact that it burned brought a turning point."

Throughout the late 1960s, scientists at the Cornell Aeronautical Lab tested oil skimmers with the hope that they could collect the oil for removal. These were carried out at a number of locations along the river and executed using stainless steel, chrome-plated drums that could float. Each buoy-mounted skimmer was just shy of 10 inches in diameter and 2 feet long and equipped with windshield wiper motors that had been rigged to spin in one direction instead of the typical back-and-forth motion.

But when attempts were made to analyze the samples collected to figure out the oil-to-water recovery ratio, Baier and others found that all the oil had just congealed to the skimmer blades. This pointed to a need for some type of chemical agent that could concentrate the oil so that it could be easily collected by the skimmer.

The solution was to use piston films. One that Baier invented, called Surface Magic, was marketed elsewhere in the nation as a way to clean up oil slicks. Though it's not used as widely today, it can be found around Florida swimming pools where it is used to concentrate leaves and other debris that falls in so that it can be filtered out by the pool's system.

"You would spray it onto the surface and it would take over and compress it into a sludge to collect it more efficiently," said Baier. "There was a great urgency in the city at the time because gas stations were leaking into the sewer system. What we were able to do was take Surface Magic, add it to the gas station line and then it took hold and drove it out to the Buffalo River where we would hold it in an air barrier. Then we'd hire a cleanup service to remove it." A chemical constituent of Surface Magic, he says, was used to treat waters after the Deepwater Horizon oil spill.

In addition to the air barriers and Surface Magic, he and other researchers installed a floating buoy in the center of the Buffalo River with a fluorescent sensor interface to catch spills before they got too far downstream. The sensor utilized an argon lamp that emitted ultraviolet light through the oil slicks. That technology would later be scaled up so that it could be used in sterilizing medical equipment. The purple glow, it seems, is very good at killing "super bugs," he says.

Photo: U.S. Army Corps of Engineers



Polluted water (discolored area) flows into Lake Erie through the Buffalo River, August 1973.

The oil slicks were so common that people just assumed there would be slicks. And it was clear that there was still more that needed to be done to rid the Buffalo River of the contaminant.

"All that ooze and grease going in all the time, we started putting detectors in the sewer lines to stop the overflows," said Baier. "Once we put up the detectors, a lot of the gas stations started to work more carefully. Once we put up a box just marked with 'detector' on a pole and the gas station stopped dumping. If you think you're being watched, you don't do these things."

The oil slicks were the most visual representation of the problems that the Buffalo River was facing, and Baier's work revealed useful methods for removing and managing them. But that was just one facet of the Buffalo River's turnaround. There was still a lot of groundwork to be done.

Baier says that Jack Kemp's work played a big role in securing grants that would cover some of the costs associated with cleaning it up further. "It took a lot of political might to develop the constituency at the D.C. side," said Baier. On the local side, he says that folks at the Buffalo Niagara RiverKeeper should get a lot of credit for the work they've done.

#### DECADES LATER

Fast forward to the 1990s and the Buffalo River is a different waterway. The oil slicks of the 1970s are gone, and so are many of the plants that used to pollute the river so frequently. Tom Diggins is a newly minted doctoral student at the University at Buffalo and is conducting research into the Buffalo River's benthic fauna.

For that work, he and others ventured out into recently dredged channels to sample the various tiny life forms that survive there, like midges and sludge worms. Their tools of choice included ponar grab samplers, which allowed them to take direct samples from the Buffalo River's streambed.

The funny thing about the Buffalo River, he says, is that its hydrology is such that it acts more like a lake than a river when you approach studying it. So using other methods for studying the fauna, like plate samplers (also called Hester-Dendy samplers) wouldn't work the best.

"Because of the situation, the Buffalo River acts more like a lake than a stream. You could put plate samplers in a powerful river and not get anything," said Diggins, now a professor of evolution and ecology at Youngstown State University. "But we got down in the sludge and we used little grab samplers to take direct bottom samples. I'm kind of a proponent of in-situ sampling across the board."

The sludge was then run through a 500-micron-mesh filter to sift out its contents, which were identified and counted back in the lab. The results of the survey, completed between 1990 and 1994, showed a couple things.

For one, the sedimentary environment outside of the Area of Concern was much healthier

than the one inside it. For another, the most impacted areas didn't exactly follow close to where the point sources had or were putting pollutants into the waterway.

"It ranged from bad to not the worst in the Great Lakes," said Diggins. "You could put it in the upper quartile, but it was not as bad as the worst."

After 10 years went by, it was time for Diggins and others to assess the health of the river's benthic fauna once again. Only this time the goal was to figure out which areas would be the most ideal for habitat restoration, in a work partnering with the Buffalo Niagara RiverKeeper.

"In the 1994 work, we were looking at a dredge channel. In the '03, '04 work, the focus was on the benthic fauna at shoreline areas," said Diggins. "At best, we could see near the shoreline that substrates had better communities than out in the dredge channel. But they were no better than they were in the 1990s. They were dominated by sludge worms with mouthpart deformity frequencies that were pretty comparable to the 1990s."

Diggins says that he would like to start another assessment of the river's benthic fauna relatively soon if he can secure funding. It would maintain the nice 10-year gap he's been able to keep between his first two studies, and it's time to see what changes there are.

Back in the 1960s and 1970s, the river's benthic communities were dead. From that point on, investigations have shown that there's been a pretty steady increase in environmental quality. The river has during that time transformed into a functioning, yet still badly impaired waterway.

Towards the beginnings of the river's rebound, it clearly had nowhere to go but up. Nowadays, Diggins thinks the gains may be harder to achieve.

"We may be in that situation because the Buffalo River's habitat is still altered by human activities," said Diggins. These include dredging that removes sediments to maintain turning channels for freighters shipping goods through the meandering and once wetland-nourishing Buffalo River. "We probably are continuing to get water or sediment improvements, but we're not getting habitat improvements."

Some of that has to do with the influx of invasive species living in and around the waterway. Diggins has seen the extent of these firsthand during a sampling trip with some biology students.

One of his students, he says, was standing on a nearby shoreline assessing something when he snapped a few photos. After getting back to the lab and reviewing the scenes, Diggins found that the river was much more impacted than it seemed from a quick glance.

"There should be native trees, willows and plants. The problem is you get Eurasian watermilfoil, phragmites, purple loosestrife. When our botany student was out there when we were doing a semi-quantitative assessment of flora (in 2004), there are trees of heaven, Japanese knotwood, phragmites and purple loosestrife, Eurasian milfoil behind him," said Diggins. "It was 100 percent invasives. So any habitat assessment will have to take into account that there are invasive species out there. We've got to get native species back in there to stave off the invaders."

In addition to bringing back the native species, Diggins has some other suggestions for improving the Buffalo River's health further. They relate to re-naturalizing the river, or essentially letting it run wild. All the dredging that is done to make turning areas for freighters, he says, could be stopped to allow the river's wetlands to come back.

In past decades, a meandering Buffalo River built wetlands through sediment deposition, providing habitat for benthic fauna that form the base of its food chain. Not only that, but healthy wetlands tend to equal cleaner water, as they act as natural filters to remove toxins and contaminants.

"The meanders are already there. They've been exaggerated for turning basins of the freighters, but they'd fill in if we stopped dredging them," said Diggins. "They would re-naturalize because they're so unnatural today. The sediments from upstream would come down and build wetlands. Every time we're out there, we see waterfowl -- the wildlife will be there if there's habitat."

#### CURRENT DAY

There's more work to be done to fully restore the health of the Buffalo River.

Dredging, though it may be bad for sediment deposition and the construction of wetlands in the long run, has been a useful tool for removing a great deal of contaminated sediments that lingered after the river's industrial heyday. The bulk of that dredging work, according to the U.S. Environmental Protection Agency, wrapped up in 2014.

More current remediation work aims to continue cleaning up the river, restore habitat along its banks and in the water, as well as continue monitoring its health. From there, officials involved with its cleanup are hopeful its Area of Concern could soon be delisted. The return of safe fishing and swimming may also happen within five to 10 years.

Instead of the steel plants and the oil factories that once lined the river, new and greener industries are popping up. There is a major solar panel maker that has recently set up shop, Baier says.

There is also a growing push to turn areas along the riverfront back into usable space for residents and visitors to the city, with hopes of creating robust economic activity in cleaner ways than those of the past.

This is marked by a stream of improvements that have made the Canalside area a hip destination for people looking to get out and once again enjoy the riverfront. The area was set up as the heart of Buffalo, New York's waterfront revitalization push, and boasts events year round, like concerts, and other attractions like ice skating, strolls along the boardwalk and food vendors.

"There is visual access to Canalside," said Baier. This came after the destruction of the Buffalo Memorial Auditorium, the old home of the Buffalo Sabres professional hockey team. "That building was completely flattened and the area was rediscovered. We have tourists here now where we used to have piss and corruption." 

## BUFFALO RIVER RESTORATION

Restoration work along the Buffalo River since 2011, with data from Ecology & Environment, Inc. GIS Department.



Photo: George Burns / U.S. Environmental Protection Agency

Map: Nate Christopher / Fondriest Environmental



**WATCH. RECORD. SHARE.**

# THE ULTIMATE FISH FINDER

FishSens Technology's new SondeCAM HD Underwater Camera adds new features, integrated WiFi and smartphone apps for a solid user experience.

BY DANIEL KELLY

After FishSens Technology released the SondeCAM Underwater Camera, it wasn't long before anglers of all stripes started dropping theirs into the water every time they went out on their boats to see exactly what they were fishing for. They love the camera's durability and the videos they get directly on their fishfinders.

Following up on that popularity, the company has released the all-new SondeCAM HD Underwater Camera, which features the latest in image-sensing technology for clear-color, high-definition visuals in any light condition. The SondeCAM HD adds a host of new features for a better user experience while retaining the rugged durability that customers expect.

This comes through the camera's marine-grade anodized aluminum body that has been streamlined with

hydrodynamics in mind. It can operate in marine or freshwater environments, with cables available up to 75 feet, and doesn't flinch when it hits concrete piers or rocky bottoms. In addition, its power and signal cable has a high-flex design with an abrasion resistant polyurethane jacket.

"It's a tough camera, and that is something that people seem to love about it. The housing helps with that, but the front bumper that protects the recessed camera lens is important too," said Trevin Fondriest, general manager at FishSens Technology.


The design also seems to blend in well with swimming fish around, Fondriest says, and he's actually seen a few swim toward the camera. That's something other underwater cameras on the market can't always guarantee.

The camera can be used by fishermen of all levels, as well as fisheries managers and researchers looking to profile submerged structures or identify fish species or habitat.

It connects to popular fishfinders, but the SondeCAM HD also comes with an integrated WiFi module that makes it easy to stream videos directly on mobile devices using the free SondeCAM App. From there, users can view, record and share videos from anywhere. The SondeCAM App is now available on the Apple App Store and Google Play.

"A lot of our customers have smartphones and want the ability to share videos they take with friends," said Fondriest. "The SondeCAM HD and app come together to make that easy. So even if you don't have a fishfinder, you can still take great video and scope out the best spots to cast to."

The camera works well in a range of aquatic conditions and is powered directly from a boat's 12VDC power source using an included cable. SondeCAM HD is compatible with many popular smartphones, tablets, fishfinders and chartplotters. Compatible fishfinders / chartplotters include Lowrance, Raymarine, and Garmin models with video input via RCA or BNC connectors.

The SondeCAM HD Underwater Camera is made in the U.S.A. and available on the FishSens website for \$499. 

## WHAT THE PROS ARE SAYING

“SondeCAM HD is the real deal. Making underwater videos has never been easier and high-def really brings everything underwater to life.”

-Brandon Card  
Bassmaster Elite Series Angler



# ROCK FALLS

U.S. Geological Survey and park scientists complete a three-and-a-half year study finding temperature's role in rock falls in Yosemite National Park.

BY DANIEL KELLY

Photo: David Iltif / CC BY-SA 3.0

Photo: Valerie Zimmer / U.S. Geological Survey

For more than 100 years, geologists have guessed at the roles that temperature plays in causing rock falls. The idea was that heating and cooling in some way contributed to the expansion and contraction of the rock faces to weaken them over time and cause them to fall.

But there hasn't always been the instrumentation needed to test those ideas, and there was pretty much only one way to get the data necessary: rock climbing. For some, that is not the most exciting way to spend a day at the office. But for two geologists who have just wrapped up a long-term study of thermal dynamics and the roles they play in rock falls at Yosemite National Park, making the climb was an afterthought.

"Neither my coauthor or I thought twice about placing the sensors on the cliffs. It seemed like the right way to do the experiment," said Brian Collins, research civil engineer with the U.S. Geological Survey who completed the work with Greg Stock, park geologist at Yosemite. "Every time we would download a data set, we had to climb. When we installed the sensors, we were hanging from a cliff."

This took place along a slab of granite that has been separating slowly from a rock face in the park for years. It's about 19 meters tall, 4 meters wide and 10 centimeters thick, Collins says. Because of its shifts over time, there is a small crack behind it that the researchers wanted to monitor.

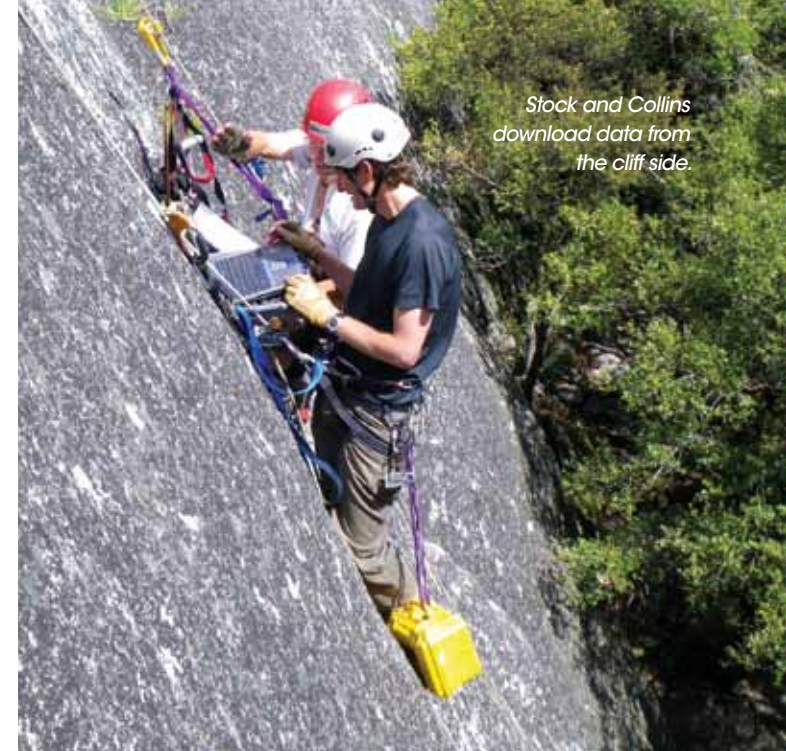
But their efforts didn't just cover one or two seasons. In order to get a concrete idea of how thermal expansion and other things affect the slab, Collins and Stock tracked the changes it experienced over three-and-a-half years using a variety of instruments.

Behind the slab, they ran wire strain gauges to measure how much the crack opened and closed. Temperature sensors were placed along the front of the rock section as well as behind it to see what heat differences there were. The researchers tracked light intensity because they were curious if solar radiation played a role, and they also measured humidity.

"We wanted to understand and assign triggering mechanisms to find out what would cause rock falls in the summer time," said Collins. "There were no explanations for some of the rock falls that we were seeing. That, combined with some anecdotal evidence from rock climbers who had placed their gear in the area and come back to find they couldn't get it out — we knew that opening and closing could be happening."

But since no one had set out to study these dynamics before, scientists weren't sure what to expect they'd find. There was some thought that the crack behind the slab might expand a small amount with more heat. But that and other questions, like the effects of solar radiation and humidity, required taking direct measurements over the course of years.

Their effort was special for the long-term approach that it took to gathering the data, which made it possible for Collins and Stock to identify trends that shorter studies might not have been able to convey. They sought to answer two questions. One, would they be able to measure the deformation in the rock? And two, would their measurements be meaningful in explaining that the separation was sufficient enough for causing rock falls?



Stock and Collins download data from the cliff side.

"We processed all that data to see how it could cause cracks," said Collins. "And we used a lot of things to figure that out, including thermodynamics, fracture mechanics and structural mechanics."

There were no correlations between humidity and the deformation, researchers found. That makes sense, Collins says, because Yosemite National Park is a pretty dry place. For the impacts of solar radiation, he and Stock found that those were not as influential in the crack's expansion as temperature was.

"The biggest surprise, in the first month of data, we had the instruments designed to measure a fraction of a millimeter," said Collins. That is how much they expected that the crack would expand. "Instead what we found was that it was moving much, much more, about a centimeter each day. That was a real eye-opener, and we even second-guessed our data." Terrestrial LIDAR would confirm that their readings were accurate, however.

Collins says another surprise was that the slab cumulatively moved out with the seasons and year over year. And so the magnitude of the deformations was much larger than had been expected.

These findings are useful for a couple reasons. For one, there's now a viable cause for the rock falls that Yosemite National Park sees in the summer time, which could help in protecting its visitors.

"When we think about hazards, we need to know what's causing the rock falls before we can assume when they might occur. This study is a step in that direction," said Collins. "And it has some applicability for explaining why rock falls continue to happen. It's different than what people assume weathering is. People would assign it as rain getting into cracks over time, but we think that thermal stress indicators on these cracks may also have something to do with the weathering process."

Full results of the study are published in the journal *Nature Geoscience*.

# IN THE GREAT LAKES



## RESEARCH FROM AROUND THE BASIN

### SUPERIOR

Researchers at Michigan Technological University have led an investigation into legacy mercury deposits existing around Lake Superior. The scientists began by taking sediment cores in old mine tailings buried at the bottom of the Keweenaw Waterway and Torch Lake, both of which are near to the university's campus. The dozens of cores they collected were each 5 centimeters in diameter, and analyzed back in the lab to assess mercury left in the cores over time. Some key questions the researchers sought to answer included how much total inorganic mercury was there, and how long it took to be deposited. From there, they compared those data to information on methylmercury concentrations and found that methylation (process making inorganic mercury organic and toxic) took place 20 to 40 years after the mining operations had ceased. As to why there is such a lag between the deposition of the mercury and when it methylated, the scientists are not yet sure.

*W. Charles Kerfoota, Noel R. Urban, Cory P. McDonald, Ronald Rossmann, Huanxin Zhang (2016). Legacy mercury releases during copper mining near Lake Superior. Journal of Great Lakes Research.*

### MICHIGAN

A study led by researchers at University of Notre Dame considered painted turtles and snapping turtles from a number of Lake Michigan wetlands. Scientists gathered turtles from wetlands around the mouths of the Grand, Muskegon and Kalamazoo Rivers. Additional wetland sites considered sat around Mona Lake in Muskegon County, Mich. The wetland sites were chosen based on the types of land use surrounding them, such as industrial or urban. At these wetlands, researchers assessed turtle shell and claw fragments. Shells and claws were commonly clipped so that most of the turtles weren't harmed. A few were sampled for tissues, however. Researchers found that the metals measured in the claws and shells matched with levels found in tissues. That confirms the method is just as reliable as turtle tissue analysis, without the injury risk.

*Dayna L. Smith, Matthew J. Cooper, Jessica M. Kosiara, Gary A. Lamberti (2016). Body burdens of heavy metals in Lake Michigan wetland turtles. Environmental Monitoring and Assessment.*

### HURON

Lake trout, lake whitefish and cisco fish in Lake Huron may have glaciation to thank for their present-day spawning grounds, according to a recent study from U.S. Geological Survey (USGS) scientists. Paleo-ice streams, researchers say, may have formed much of the crucial egg-laying habitat the fish depend on. The ice streams are corridors within ice sheets that move more quickly than surrounding ice. The streams operated sort of like arteries. They cut paths into the ground, dislodging and moving things as they went. To test their involvement with present-day spawning areas, USGS researchers compared trout, whitefish and cisco spawning sites to surface sediments and to the estimated locations of ancient ice streams in what is Lake Huron today. The efforts revealed that the spawning habitats likely formed within beds of the ice streams around 22,000 to 13,000 years ago.

*Stephen C. Riley, Thomas R. Binder, Taaja R. Tucker, John Menzies, Nick Eyles, John Janssen, Andrew M. Muir, Peter C. Esselman, Nigel J. Watrus, Charles C. Krueger (2016). Islands in the ice stream: were spawning habitats for native salmonids in the Great Lakes created by paleo-ice streams? FISH and FISHERIES.*

### ONTARIO

Nitrate concentrations in offshore waters of Lake Ontario have increased by approximately 60 percent between the 1970s and 2000s, although the drivers are unclear. Scientists at Trent University show that nitrate concentrations also increased significantly in at least one season at 13 of 15 large southern Ontario tributaries that drain into Lake Ontario that have no known upstream wastewater treatment plants. Average nitrate concentrations more than doubled between the 1970s and 2000s at some streams. Only the two most urbanized streams did not show any increase in nitrates, which declined at the most urbanized catchment in the study, Sheridan Creek. Agriculture is the predominant form of human activity at the 13 watersheds where nitrate increased, accounting for 51 to 71 percent of total land cover. Both the total area of agricultural land and the type of agriculture have changed dramatically in southern Ontario; and these shifts could alter nutrient transfer to waterways.

*M. Catherine Eimers, Shaun A. Watmough (2016). Increasing nitrate concentrations in streams draining into Lake Ontario. Journal of Great Lakes Research.*

### ERIE

In 2014 and 2015, scientists led by the Ontario Ministry of Natural Resources surveyed 27 sites in Rondeau Bay, Ontario, Canada, for freshwater mussels. Rondeau Bay is a large coastal wetland on the north shore of Lake Erie. Twenty-three species were identified from 120 live mussels, 15 fresh whole shells, 329 weathered whole shells, and 1121 weathered valves. Live individuals of the following species were collected: Eastern Pondmussel (*Ligumia nasuta*; endangered in Canada), Giant Floater (*Pyganodon grandis*), Round Pigtoe (*Pleurobema sintoxia*; endangered in Canada), and Threeridge (*Amblema plicata*). Fresh whole shells of the Mapleleaf (*Quadrula quadrula*; threatened in Canada) were also found. Most species (78 percent), including seven species at risk, were collected only as weathered shells. These results indicate a substantial decline in freshwater mussel diversity since the Zebra Mussel (*Dreissena polymorpha*) invasion of Lake Erie. Evidence shows that a viable population of only Giant Floater remains.

*Scott M. Reid, Victoria Kopf, Anita LeBaron, Todd J. Morris (2016). Remnant Freshwater Mussel Diversity in Rondeau Bay, Lake Erie. The Canadian Field-Naturalist.*

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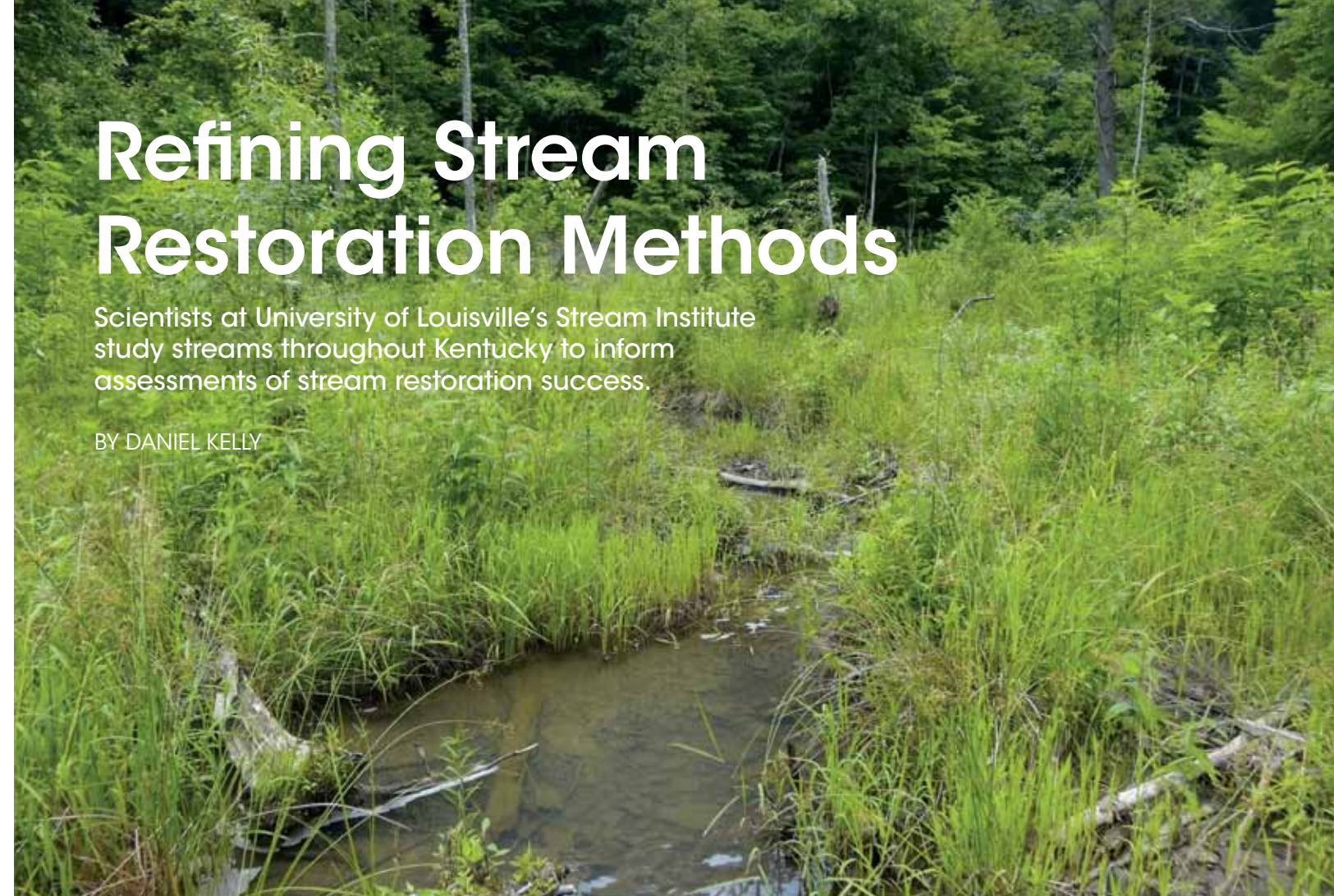
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# Refining Stream Restoration Methods

Scientists at University of Louisville's Stream Institute study streams throughout Kentucky to inform assessments of stream restoration success.

BY DANIEL KELLY



A lot of work goes into stream restoration projects, but how do you know if all the effort is yielding ecological benefits? That is one of the many questions that researchers are tackling at the University of Louisville Stream Institute.

To get at the answer, they have devised experiments that compare conditions in restored streams to others that have not been remediated or will be soon. These unrestored streams help to serve as baselines for comparisons that could inform new stream restoration methods in the future.

Researchers routinely track streams for important parameters relating to stream health, including temperature, dissolved oxygen, conductivity and suspended sediments. But they also learn a lot just from gauging a stream's depth, for which they typically use pressure transducers.

"We are primarily using the APG PT-500 (transducers) in sites which have been or will be restored to a stream-wetland complex using valley restoration techniques, as well as similarly situated sites, unrestored sites which represent a baseline condition for comparison," said Jesse Robinson, research project engineer at the stream institute. "We are working on a project for the Environmental Protection Agency (Region 4) where we will use data from all of these sites to develop stream restoration assessment methods."

Those sites are mostly in Kentucky, in steep streams that have varying sediment characteristics. Whereas some are dominated

by sand, others are more filled with silt or clay. The unrestored streams can sometimes transport boulders during large flood events, he says.

By continuously measuring depth in the streams, researchers and staff at the institute can keep an eye on flooding as well as other hydrologic conditions that the sites can experience, like drying out or receding.

"These conditions are the foundation for everything that occurs within the stream, including, for example, whether habitat and food sources will remain in place for aquatic life or be scoured during floods," said Robinson.

Data on depth they've collected have revealed some insights about the streams under study in Kentucky, as well as a few surprises.

"We were aware that small, frequent floods were moving aquatic habitat around in some of our un-restored sites, but we were surprised to see how frequently — seven times and counting in a single year — this was happening," said Robinson. "We do not see this movement in our nearby restored sites. The APG PT-500 helps us understand the kinds of floods we are seeing in terms of their frequency, duration and magnitude, which we pair with bedload transport sensors to know when aquatic habitat is moving."

Photo: Jesse Robinson / University of Louisville



INDUSTRY  
PROFILE

# Q&A

## Krystopher Chutko

Krystopher Chutko is an assistant professor in the Department of Geography and Planning at the University of Saskatchewan. Together with researchers from Nipissing University, he is using data buoys, temperature strings and water quality sondes to study mixing events and how they affect nutrient availability in Ontario's Lake Nipissing.



### **Environmental Monitor:** Where do you track temperatures in Lake Nipissing?

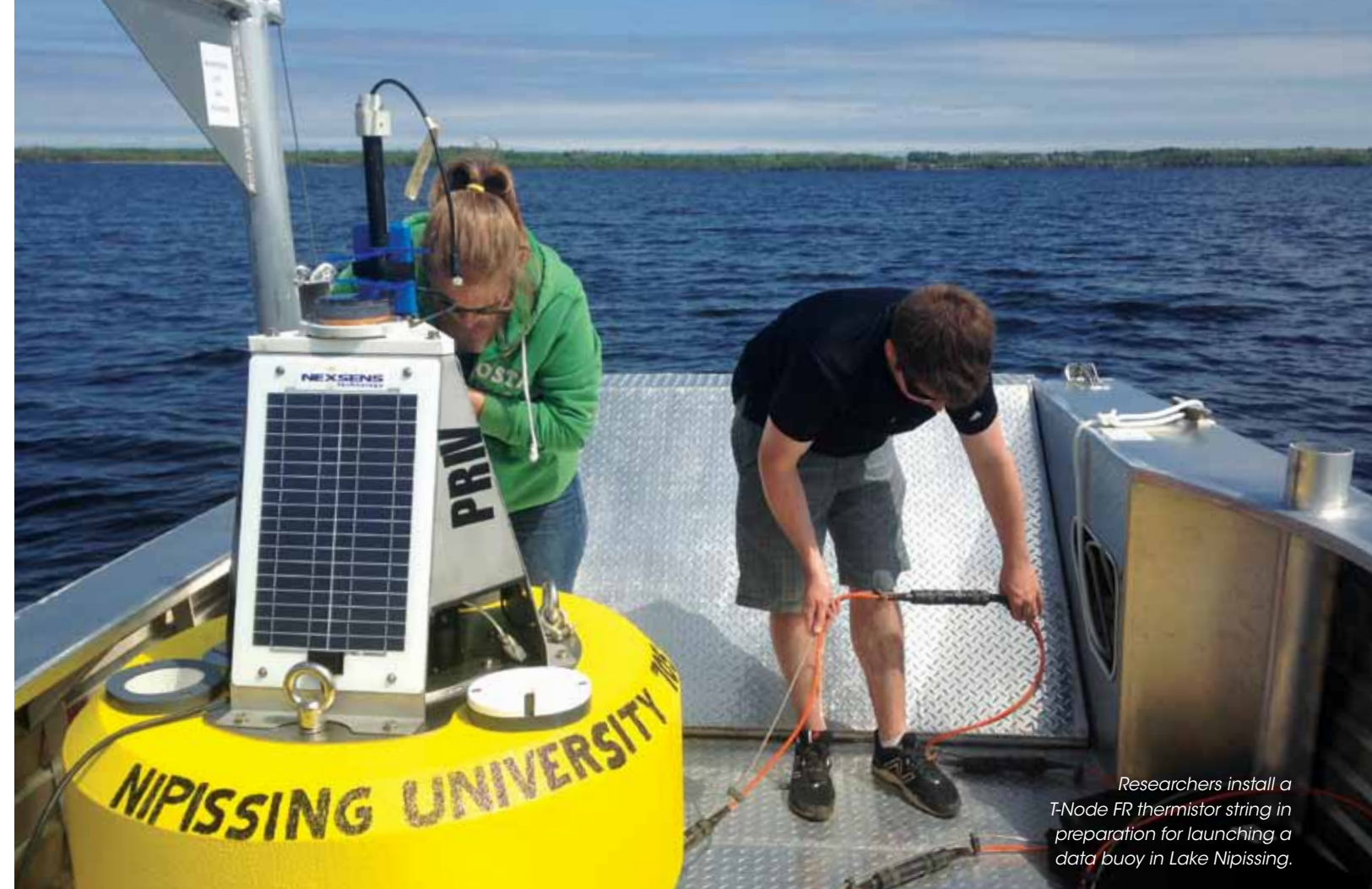
**Krystopher Chutko:** Our T-Nodes are deployed in two locations in Lake Nipissing, central Ontario. One is in the center of Callander Bay, while the other sits between the Manitou Islands and the city of North Bay. Both are in 10 meters of water. These two sites represent distinctly different regions of the lake – that Manitou site represents the open water part of the lake while Callander Bay is a relatively isolated embayment.

### **EM:** Why is it important to track temperatures in Lake Nipissing?

**KC:** T-Nodes are an important component of the instrumentation that we deploy to monitor stratification and mixing events in the lake. Stratification and mixing events influence dissolved oxygen and nutrient availability. Several of the isolated bays surrounding Lake Nipissing, including Callander Bay, experience occasional cyanobacteria events, some of which can be toxic. Callander Bay is the drinking water supply for the Municipality of Callander, an important recreational fishery (both summer and winter), and overall tourist destination. There has been no effort to assess the importance of internal phosphorus loading in the embayment. Our basic premise is that during periods of stability, the stratified water at the bottom becomes anoxic (less than 1 mg/L of dissolved oxygen). During this time, phosphorus bound to sediments becomes mobile and enters the water column, providing a nutrient source for the cyanobacteria, potentially leading to a bloom. We use the T-Nodes to monitor the temperature profile at the sites at high frequency (every 10 minutes) so that we can identify the particular controls of mixing at those sites, such as wind and rain to model the potential influence on the presence of cyanobacteria. We use the Manitou site as a control location, while Callander Bay is our primary site.

### **EM:** What other conditions are you tracking?

**KC:** At each of our two sites, we have a data buoy, outfitted with a data logger, water quality sonde (measuring near-surface water temperature, turbidity, dissolved oxygen, chlorophyll-a, pH and conductivity), the T-Node chain and dissolved oxygen just above the bottom sediment surface. Additionally, each buoy has a weather station measuring air temperature,



*Researchers install a T-Node FR thermistor string in preparation for launching a data buoy in Lake Nipissing.*

humidity, pressure, wind speed and direction and rainfall. All of these sensors record every 10 minutes and we typically deploy them from late May to late October.

### **EM:** Who is involved in data collection on Lake Nipissing?

**KC:** This research project involves many people from many organizations. The principle researchers are Dr. April James and Dr. Dan Walters from the Department of Geography at Nipissing University, and myself. Each summer, we have a team of students who assist in setting up, deploying and collecting data from the buoys. This project is both an important piece of research but also a teaching and learning environment for our students. We also have worked closely with partners at the Ontario Ministry of Environment and Climate Change, and with the Ontario Ministry of Natural Resources and Forestry.

### **EM:** How do you use the data that you collect?

**KC:** The data are currently used for research purposes. We collect the data, analyze it and present results at international conferences. Megan Prescott completed her Master's of Environmental Science degree at Nipissing University using data collected from the buoys. I recently presented the data at the International Association of Great Lakes Research meeting in Guelph, Ontario. The data is also made available for public use online (buoys.nipissingu.ca). The online data is made available by Dr. Mark Wackowiak and his students in the Department of Computer Science and Mathematics at Nipissing University. In the future, we hope to use this data as a tool to predict cyanobacteria blooms.

### **EM:** Do you have any results to report so far?

**KC:** We have presented results at a few conferences so far and future publications are in the works. Although I wouldn't call it surprising, we do see a strong relationship between the stability of the water column and what we are calling wind and/or rain "events." We identify these events and meteorological phenomena greater than one standard deviation above the norm. For instance, an extended period of above-normal winds are strongly related to periods of water column mixing, while periods of below-normal winds are related to stratification and stability. Similarly, heavy rainfall is related to mixing. It is likely these two parameters are correlated as well, since in central Ontario heavy rainfall is usually associated with convective storm systems that typically come with high winds.

### **EM:** Who is supporting your research efforts on Lake Nipissing?

**KC:** This work certainly could not have been started or continued without the ongoing financial support from Nipissing University, the Natural Sciences and Engineering Research Council, the Canadian Research Chairs program, the Canadian Foundation for Innovation and the Ontario Ministry of Environment and Climate Change. I also can't stress enough the important role that students play in this work. They have been involved in all aspects of the science and have all made valuable contributions to keeping the project moving forward. Since university students come and go quickly, there have been too many involved in this project to list, but they are all part of the team. ☺

*Photos: Krystopher Chutko / University of Saskatchewan*





NEW  
TECHNOLOGY



## Environmental Sample Processor

A few years back, the Environmental Monitor covered the environmental sample processor (ESP) as it embarked on an effort to study the microbial life of the Columbia River Estuary. But nowadays, this relatively new type of monitoring platform is ready for a bigger job: deployment in the ocean.

In late May, scientists with the University of Washington and the National Oceanic and Atmospheric Administration (NOAA) launched an ESP off the coast of La Push, Wash. in a bid to stay ahead of algal blooms and the toxins that sometimes come with them.

The device was deployed with sensors to monitor specific algal species and a harmful toxin they emit called domoic acid. The tool will provide autonomous, near-real-time measurements of the amounts of toxin and the concentrations of six potentially harmful algal species.

The ESP was placed 13 miles offshore in the Olympic Coast National Marine Sanctuary. It is near the Juan de Fuca eddy and in a known transport path where offshore *Pseudo-nitzschia* blooms – a common Pacific harmful algal species – travel to coastal beaches where they can contaminate shellfish. It sits about 50 feet below the surface near the ChaBa buoy, a mooring deployed in July 2010 that tracks surface water carbon

dioxide and pH as well as surrounding atmospheric carbon dioxide and other parameters.

The tool was developed at the Monterey Bay Aquarium Research Institute (MBARI) to automate water-testing that normally requires a boat trip to sea and then analysis in a lab. MBARI scientists helped install the ESP that will beam results back to shore three times a week for six weeks. The research team will collect the tool in July 2016 and then deploy another ESP to monitor during the late summer season.

The push to put in place new technology to monitor harmful algal blooms in the Pacific Northwest comes after a severe harmful algal bloom season in 2015 and worries that such events could become more common under climate change.

The real-time data on bloom toxicity and algal species biomass will be made available directly to state coastal managers and public health officials, including coastal tribes, through the website of the Northwest Association of Networked Ocean Observing Systems, or NANOOS.

Coastal managers will use the early warning data from the instrument to inform proactive shellfish toxicity testing and to facilitate timely decision-making on shellfish harvesting opportunities and closures.

Photo: Stephanie Moore / National Oceanic and Atmospheric Administration



NEW  
TECHNOLOGY



## Chemical Compounds Tracker

For common water quality parameters like pH or dissolved oxygen, there are plenty of devices out there to measure them. For low-level contaminants like pesticides, however, the situation is a little trickier.

A tried-and-true method of acquiring chemical contaminant data has traditionally involved collecting “grab samples” by dipping bottles into the target water source and then transporting those bottles, which are often very heavy when they are full of water, to a lab for analysis. The trouble with this method is that the sample is from a single point in time and may not represent fluctuations in the contaminant that occur over weeks or months. Additionally, collecting water and shipping it to a lab for analysis can be expensive and something of a hassle.

Researchers at Arizona State University have tried their hand at addressing this issue. They have developed a sampling device that integrates some of the same equipment used in the lab to enhance the signal of low-level chemical compounds; it is a device capable of collecting the chemicals directly from water, without collecting the water itself.

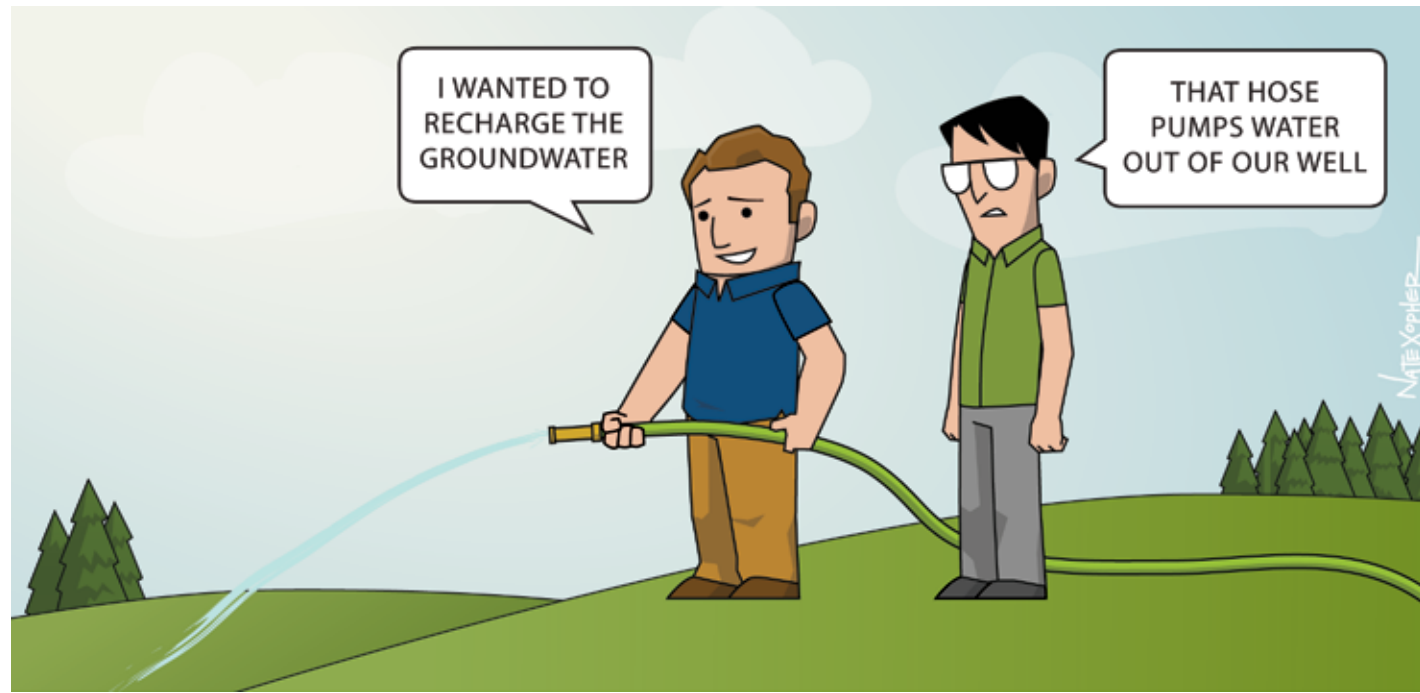
One of the key features of the device, aside from its ability to capture chemicals from water, is its unique ability to sample contaminants in bulk water and the sediment pore water (e.g., in a lake) simultaneously. The device was recently used in water-

ways of the U.S. Southwest to assess the occurrence of the pesticide fipronil, which may play a role in the plight of honeybee populations in the United States.

The device is called the In Situ Sampler for Biphasic water assessment (IS2B), and uses solid phase extraction (SPE) technology in its design to concentrate the analytes directly in the stream of interest. SPE involves passing water through a cartridge filled with a selected resin matched to the chemicals of interest. The resin adsorbs the chemicals, effectively precipitating them out of the dissolved phase. The cartridge is subsequently taken back to the lab, the contaminant extracted from the resin using standard analytical methods, and then analyzed. The initial investigation of the device’s utility, led by Dr. Samuel Supowit while a graduate student at Arizona State, showed that the approach produces reliable results.

“We’ve taken that technology and put it into a sampler so that it is done in the field. That technology is very common and as a mature technology, cartridges and resins can be purchased commercially,” said Erin Driver, a graduate research associate at Arizona State University’s Biodesign Institute.

Photo: Arizona State University



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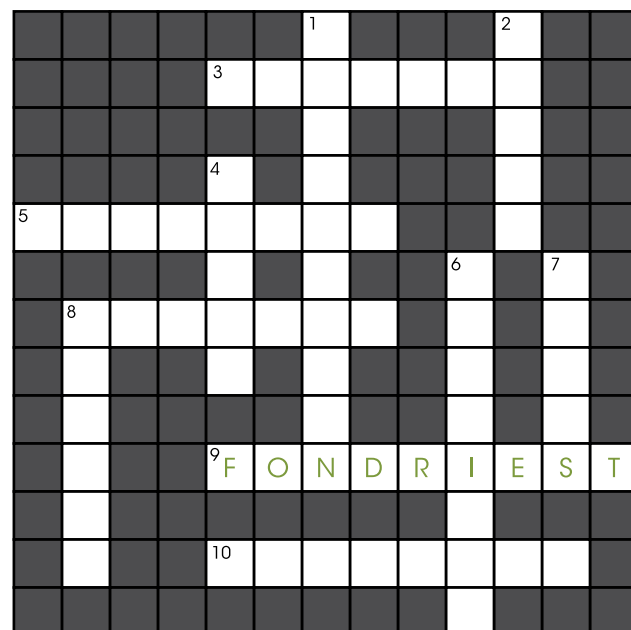
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3. Groundwater storage is greater than present \_\_\_\_ water supplies
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1. Most groundwater is used for this
2. Groundwater occurs in saturated soil \_\_\_\_ the water table
4. Pumping can affect the level of the water \_\_\_\_
6. More than 1 million households here have private water wells
7. Nearly 16 million water \_\_\_\_ serve the United States
8. Deep, underground water is typically \_\_\_\_ to the surface



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